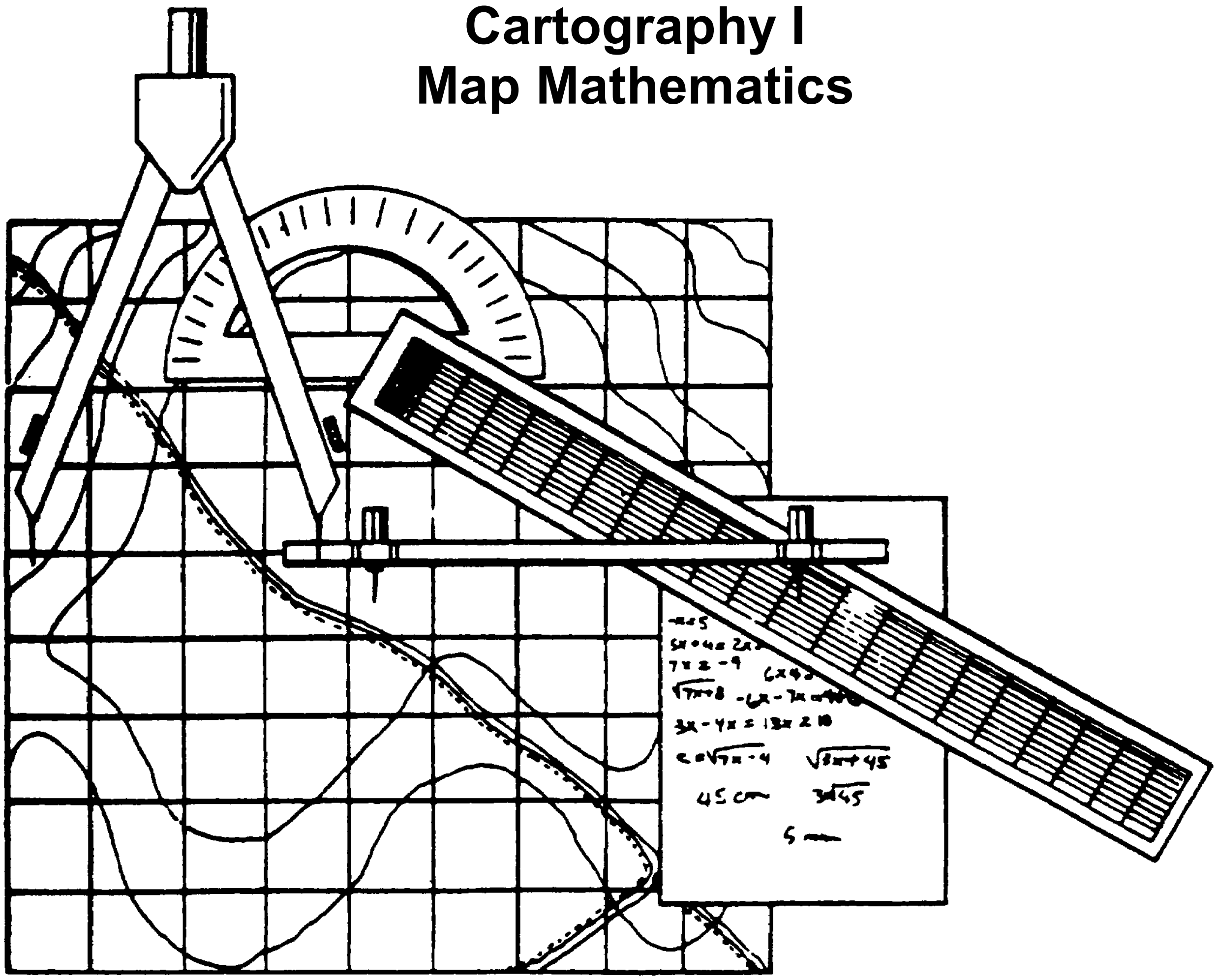
Subcourse
EN 5301

Edition
2

US Army Engineer School

Cartography I
Map Mathematics



THE ARMY INSTITUTE FOR PROFESSIONAL DEVELOPMENT
ARMY CORRESPONDENCE COURSE PROGRAM

CONTENTS

***** IMPORTANT NOTICE *****

THE PASSING SCORE FOR ALL ACCP MATERIAL IS NOW 70%.

PLEASE DISREGARD ALL REFERENCES TO THE 75% REQUIREMENT.

INTRODUCTION

1. This subcourse consists of three lessons on basic mathematic skills required by the Cartographer. These lessons will enable you to perform basic map mathematics, to work in the metric system, to convert to and from the English system, and to use measuring scales. The skills and knowledges learned in this subcourse will enable you to easily master the tasks presented in later cartography subcourses. This is a self-paced subcourse.

2. Supplementary Training Material Provided: None.

3. Material to be provided by the student:

   a. Calculator (optional)
   b. Engineer Scale
   c. Friction Dividers
   d. Paper
   e. Pencil
   f. Metric Scale

4. Material to be provided by unit: None.

5. Bound in Materials: Invar Scale.

6. This subcourse cannot be taken without the above materials.

7. Five credit hours will be awarded for successful completion of this subcourse.

GRADING AND CERTIFICATION INSTRUCTIONS

1. Instructions to the Student: This subcourse has a written performance test which covers three lessons. You must correctly perform each of the three parts to complete the subcourse. The test is a self-paced test.

2. Instructions to Supervisor: NA.

3. Instructions to Unit Commander: NA.

PRETEST

For this subcourse only one test is provided. You will be allowed to take the test without studying the material if you feel that you can correctly perform all three parts.

LESSON I

MAPPING MATHEMATICS

OBJECTIVE:	At the end of this lesson you will be able to perform mathematic computations related to basic mapping techniques.
TASK:	Related tasks. 051-257-1203 Construct Map Grids 051-257-1204 Construct Map Projections 051-257-1205 Plot Geodetic Control 051-257-2213 Determine Aerial Photography Scales 051-257-2236 Compute Enlargement/Reduction Factors 051-257-2238 Construct Controlled Photomosaics
CONDITIONS:	You will need this subcourse booklet, and will work on your own.
STANDARDS:	You must correctly answer the questions in the written performance test with 75 percent accuracy.
CREDIT HOURS:	1 1/2
REFERENCES:	None

INSTRUCTIONAL CONTENT

INTRODUCTION

Mathematics plays a major role in the cartographic phase of mapping. Nearly all work performed in the compilation phase of mapping includes some form of mathematical computation. To be a professional cartographer, you must be proficient in basic mathematics. Before taking the self-paced test you should work through the following programmed lessons.

HOW TO LEARN FROM THIS SELF-TRAINING TEXT

1. This programmed lesson may be different from any lesson you have received in the past. It is designed to be used without any supervision; however, if you have any questions they may be answered by your supervisor.

2. This programmed lesson allows you to work at your own speed. This speed will vary from person to person. Although some of the material may seem simple to you, DO NOT RUSH through it. You may review the items that you have previously studied as much as you like.

3. THIS IS NOT A TEST. It is a means of learning using a style of programming called "Linear Programming." In linear programming, each "frame," which is separated from other frames, contains a small bit of information which you will read. Then you will be required to form a response either by supplying missing words, selecting the best of a group of statements, or answering True/False questions. Think out the answer and write it in the space(s) provided. The correct answer will appear above the next frame, unless otherwise stated. If the answer that you have written is correct, go to the next frame. If your response is incorrect, <u>cross out the answer</u>, read the frame again, and write the correct answer beside the one crossed out. Then go to the next frame. You are not graded on your answers, but you should write <u>your answer</u> before checking the correct answer. Filling in the blanks is a necessary part of the programmed instruction technique.

4. <u>Do not</u> guess at any answers. You will always be given the correct answer.

5. You are now ready to begin.

a. Basic Arithmetic

Basic arithmetic and fractions comprise the first program in this lesson. Ability to accurately perform computations in each of these areas will aid you in producing correct solutions for mapping operations. By following the instructions in the program, and learning the rules for the problems involved, you should have no trouble.

START HERE

Frame 1. There are four basic operations in arithmetic: addition, subtraction, multiplication, and division. The operations are used for whole numbers, fractions, and decimals. As you progress through this program you will get acquainted with these operations on whole numbers and fractions. Continue through each frame in numerical order. Frames begin on odd numbered pages.

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16. (+12; -7; +100; +75; -180; +209)

Frame 17. Multiplication is rather easy, although it can be difficult if you let it. Multiplication is nothing more than a continuation of addition. The resulting answer is usually called the Product.

For example, if you are told to multiply +5 by +2, it is the same as using +5 as an addend 2 times.

Add	Multiply
+ 5	+ 5
+ 5	+ 2
+ 10	+ 10

With the above example in mind, the product of +6 and +4 is ____________.

---

34. (A. 51/57; B. 100/125)

Frame 35. Multiplying the numerator (or dividing the denominator) by a number multiplies the fraction by that number. For example:

1/12 x 5 = 5/12 and 1/8 x 2 = 2/8 or 1/4 or $\frac{1}{8 \div 2} = \frac{1}{4}$

Solve the following problems.

A. 9/10 x 3 =
B. 1/2 x 7 =
C. 4/7 x 28 =
D. 2/3 x 12 =
E. $\frac{9}{18 \div 3} =$
F. $\frac{4}{24 \div 3} =$

9. (3)

Frame 10. The next step is to place the sign of the greater value in front of the difference of the absolute values.

When adding +6 and -9 the sign in front of the 3 should be ____________.

---

25. (A. -240; B. -240; C. -360; D. +154)

Frame 26. Numbers can be solved by DIVISION and proved by multiplication as in arithmetic. For example:

Division	Proof by Multiplication
$\frac{+36}{+6} = +6$	$\begin{array}{r} +6 \\ +6 \\ \hline +36 \end{array}$

Solve the problem +20 ÷ +5, as in the example above. The quotient (result of division) is ________________.

---

43. (13 + 4/7 = 13 4/7

-6 7/8 - 4/3 =
-6 21/24 - 32/24 =
-6 53/24 = -8 5/24

13 4/7 - 8 5/24 =
13 96/168 - 8 35/168 = 5 61/168)

Frame 44. Multiplication of a fraction by a whole number. Multiply 3/9 by 4. To multiply 3/9 by 4 is to find a fraction 4 times as large as 3/9.

3/9 x 4 = 12/9 - 1 3/9 = 1 1/3

Solve 7 x 3/5 _____________________.

1. (No response)

Frame 2. The absolute value of a signed number is the numerical value, regardless of the sign. Without regard to the sign in front of a signed number, the absolute value is the ____________ that follows the sign.

---

17. (+24)

Frame 18. The same procedure would be used to multiply -5 by +2. The example below shows the comparison.

Add	Multiply
$-\ 5$	$-\ 5$
$-\ 5$	$+\ 2$
$-\ 10$	$-\ 10$

Referring to the above example, multiply -6 by +3. The result is ________.

---

35. (A. 27/10 or 2 7/10; B. 7/2 or 3 1/2; C. 112/7 or 16; D. 24/3 or 8; E. 9/6 or 1 1/2; F. 4/8 or 1/2)

Frame 36. Dividing the numerator (or multiplying the denominator) by a number divides the fraction by that number. For example:

1/6 ÷ 2 = 1/12 and
7/8 ÷ 4 = 7/32 or

$$\frac{7}{8 \times 4} = 7/32$$

Solve the following problems.

A. 1/9 ÷ 3 =
B. 7/12 ÷ 4 =
C. 6/7 ÷ 7 =
D. 7/12 x 1/4 =
E. 6/7 x 1/7 =

10. (minus)

<u>Frame 11</u>. When adding positive and negative numbers, regardless of the number of addends, you still find the difference between the absolute values. The examples below illustrate.

<u>Two Addends</u>	<u>More Than Two Addends</u>	
$\begin{array}{r} +7 \\ \underline{-3} \\ +4 \end{array}$	$+10 \quad \begin{array}{c} (+6) \\ (-9) \\ (+4) \\ \underline{(-3)} \end{array} \quad -12$	$\begin{array}{r} +10 \\ \underline{-12} \\ -2 \end{array}$

Add the problems listed below.

$\begin{array}{r} -7 \\ \underline{+3} \end{array} \qquad \begin{array}{r} -9 \\ +6 \\ -4 \\ \underline{+2} \end{array}$

---

26. (+4)

<u>Frame 27</u>. Now as you proceed, you will note that the rule for division is the same as for multiplication. For example, dividing like signs will give positive answers.

$+20 \div +4 = +5$

The quotient (result of division) of -15 divided by -5 would be __________.

---

44. (7 x 3/5 = 21/5 = 4 1/5)

<u>Frame 45</u>. Multiplication of a fraction by another fraction is simply the operation of multiplying the numerator of one by the numerator of the other, and placing this value over the product of the denominators. Multiply 7/9 by 3/4.

7/9 x 3/4 = 21/36 = 7/12

Remember to reduce to <u>lowest terms</u>.

Solve 8/11 x 5/6 __________________.

2. (number)

Frame 3. Write the absolute value of each number in the space provided in front of the letters.

______ A. +127 ______ B. -15

______ C. +1/2 ______ D. +0.3

______ E. -1.6 ______ F. -6 1/3

---

18. (-18)

Frame 19. The first rule of multiplication is that like signs will give positive answers. The examples below will illustrate.

+5 x +4 = +20

-3 x -4 = +12

The sign of the product of two negative or two positive numbers will be ______________________________.

---

36. (A. 1/27; B. 7/48; C. 6/49; D. 7/48; E. 6/49)

Frame 37. When it is necessary to express an answer by a fraction, the fraction is usually reduced to its lowest terms. For instance, 40/60 = 4/6 = 2/3.

Reduce the following fraction to its lowest terms: 336/384 = ______________.

11. (-4; -5)

Frame 12. Solve the problems below by addition.

$$\text{A.}\ \begin{array}{r} +7 \\ -8 \\ -3 \\ \underline{+5} \end{array} \qquad \text{B.}\ \begin{array}{r} +119 \\ +221 \\ \underline{-197} \end{array} \qquad \text{C.}\ \begin{array}{r} +32 \\ -781 \\ \underline{+521} \end{array}$$

$$\text{D.}\ \begin{array}{r} +17 \\ -92 \\ -138 \\ \underline{+212} \end{array} \qquad \text{E.}\ \begin{array}{r} +833 \\ -117 \\ -291 \\ \underline{-415} \end{array} \qquad \text{F.}\ \begin{array}{r} +32 \\ +96 \\ +89 \\ \underline{-147} \end{array}$$

---

27. (+3)

Frame 28. The sign of the quotient, when like signs are divided, is __________.

---

45. (20/33)

Frame 46. Cancellation simplifies multiplication of fractions.

12/16 x 4/12 = 1/4

In the above example, the twelves cancel, and the 16 is divisible by the 4. This is a form of reducing to lowest terms. Cancellation would work as follows:

$$\frac{\overset{1}{\cancel{12}}}{\underset{4}{\cancel{16}}} \times \frac{\overset{1}{\cancel{4}}}{\underset{1}{\cancel{12}}} = \frac{1 \times 1}{4 \times 1} = \frac{1}{4}$$

Multiply 24/13 by 39/48 ____________________________.

3. (A. 127; B. 15; C. 1/2; D. 0.3; E. 1.6; F. 6 1/3)

Frame 4. The first step in adding two or more positive numbers is to find the sum of their absolute values.

To add +14 and +4, you first find the ______________________________ of their absolute values.

---

19. (positive, +, or plus)

Frame 20. To eliminate confusion as you progress through the program, you should know that multiplication can be expressed without the use of the x (times) sign. For example, multiplication can be indicated like this:

(+2)(+2) = +4 and (-6)(-2) = +12.

When you see a problem written this way: (+7)(+2), it means that (+7) is to be _______________________ by (+2).

---

37. (7/8)

Frame 38. Fractions that have the same denominator are called similar fractions or fractions with a common denominator. For example:

1/3 = 4/12 = 8/24

1/4 = 3/12 = 6/24

12 and 24 are common denominators. In this case, 12 is the least common denominator, the lowest number divisible by both 3 and 4.

Change the following to fractions with the least common denominator:

3/12 = ____________.
7/24 = ____________.
19/36 = ___________.

The least common denominator is ____________________________________.

12. (A. +1; B. +143; C. -228; D. -1; E. +10; F. +70)

Frame 13. The rule for subtraction of signed numbers is to change the sign of the subtrahend (bottom number of number being subtracted) and then proceed as in addition.

When subtracting +9 from a +12, the +9 becomes _____9.

---

28. (+, plus, or positive)

Frame 29. Solve the problems below.

A. +36 ÷ +4 =

B. -25 divided by -5 =

C. $-6\overline{)-24}$ **=**

---

46. (24/13 x 39/48 = 1 1/2)

Frame 47. The same principles apply when multiplying more than two fractions.

Solve 3/7 x 9/15 x 30/36 = _________________.

4. (sum)

Frame 5. The next step is to place the plus sign in front of the sum of the absolute values.

The sum of +14 and +4 has an absolute value of 18. To complete the problem, you place a _________ sign in front of the 18.

---

20. (multiplied)

Frame 21. The second rule for multiplication is that numbers of unlike signs have a negative product, as illustrated below.

-4 x +2 = -8

+6 x -4 = -24

The sign of the product of two numbers having unlike signs will be ______.

---

38. (18/72; 21/72; 38/72; 72)

Frame 39. In the addition or subtraction of fractions, the fractions must first be changed to fractions having a least common denominator. For example:

Add: 7/11 + 5/11 + 10/11 = 22/11 = 2

Subtract: 11/13 - 3/13 = 8/13

The sum of 7/10 + 4/12 + 19/30 = ________________________.

13. (minus)

<u>Frame 14</u>. In subtracting a -4 from a -13, the first step to follow is to change the -4 to a ____4 and then proceed as in _________________.

---

29. (A. +9; B. +5; C. +4)

<u>Frame 30</u>. Division of unlike signs can be accomplished in the same manner as like signs except you must remember: The quotient of two numbers having unlike signs is negative.

The examples will illustrate.

+25 ÷ -5 = -5

-40 ÷ +4 = -10

The quotient of +45 ÷ -9 is ___________.

---

47. (3/14)

<u>Frame 48</u>. When multiplying mixed numbers by whole or mixed numbers, change all mixed numbers to improper fractions.

For example:

9 2/7 x 5 = 65/7 x 5 = 325/7 = 46 3/7

7 1/3 x 4 2/5 = 22/3 x 22/5 = 484/15 = 32 4/15

Find the product of 5/14 x 4 2/3 x 12 = _______________________________.

5. (plus)

<u>Frame 6</u>. The second rule for addition of signed numbers is for those having two or more negative signs. The first step in adding two or more negative numbers is: Find the sum of the absolute values.

To add -6 and -9, you first find the ________________________ of their absolute values.

---

21. (negative, -, or minus)

Frame 22. Solve, by multiplication, the problems below.

A. (+12)(-4) =	B. (-6)(11) =
C. 7 x -3 =	D. 5 x 12 =
E. (-21)(-4) =	F. (18)(-6) =
G. (13)(11) =	H. (-15)(-8) =

---

39. (7/10 = 42/60
4/12 = 20/60
19/30 = 38/60
100/60 = 1 2/3)

<u>Frame 40</u>. Find the sum of 3 1/3, 5 1/11, and 2 9/22 ___________________.

14. (+, or plus; addition)

Frame 15. When you subtract -4 from -13, the result is ___________________.

---

30. (-5)

Frame 31. Find the quotient of the problems below.

A. -12 ÷ 6 =

B. $-4\overline{)\,28}$ =

C. -24 divided by -12 =

D. 35 ÷ -7 =

E. divide 63 by -9 =

F. 144 ÷ 12 =

---

48. (20)

Frame 49. To divide 3/7 by 4 is the same as finding 1/4 of the number. Then, by using the principle that multiplying the denominator of a fraction divides the value of the fraction, we have

$$3/7 \div 4 = \frac{3}{7 \times 4} = 3/28.$$

Solve 275/9 ÷ 25 = _________________________.

6. (sum)

Frame 7. The next step is to place the minus sign in front of the sum of the absolute values.

The sum of -6 and -9 has an absolute value of _______. To complete the problem, you place a _______ sign in front of your answer.

---

22. (A. -48; B. -66; C. -21; D. +60; E. +84; F. -108; G. +143; H. +120)

Frame 23. When an uneven (odd) amount of negative numbers are multiplied, their product will always be negative (-).

The examples below illustrate.

(+4) x (+2) x (-3) = -24

(-2) x (-3) x (-2) = -12

The product of (-3)(-2)(-1) is ______________________.

---

40. (3 1/3 = 3 22/66
5 1/11 = 5 6/66
2 9/22 = 2 27/66
10 55/66 = 10 5/6)

Frame 41. Subtract 4/11 from 4/5. _________________

15. (-9)

Frame 16. Solve the following problems by subtraction.

A. $\begin{array}{r} +4 \\ \underline{-8} \end{array}$	B. $\begin{array}{r} -9 \\ \underline{-2} \end{array}$	C. $\begin{array}{r} +71 \\ \underline{-29} \end{array}$
D. $\begin{array}{r} +117 \\ \underline{+\ 42} \end{array}$	E. $\begin{array}{r} -91 \\ \underline{+89} \end{array}$	F. $\begin{array}{r} +746 \\ \underline{+537} \end{array}$

Return to page 3.

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31. (A. -2; B. -7; C. +2; D. -5; E. -7; F. +12)

Frame 32. In the indicated division, 9/11, we are unable to find the quotient. This method of representation is called a fraction, in which the dividend 9, the number above the line, is called the NUMERATOR of the fraction, and the divisor 11, the number below the line, the DENOMINATOR of the fraction.

Circle those letters in front of fractions.

A. 7/9	B. 2/3	C. 6 2/3
D. 9/10	E. 12/7	F. 7

---

49. (11/9 = 1 2/9)

Frame 50. In the previous problem, we could divide the numerator (275) by 25 and thus divide the fraction.

$$275/9 \div 25 = \frac{275 \div 25}{9} = 11/9 = 1\ 2/9$$

To divide one fraction by another fraction, invert the divisor and multiply by the dividend. If either or both the dividend and divisor are mixed numbers, first change to improper fractions. Use cancellation when possible.

For example:

49/65 ÷ 14/39 = 49/65 x 39/14 = 21/10 = 2 1/10 and

4 4/5 ÷ 3 1/3 = 24/5 x 3/10 = 36/25 = 1 11/2

Solve the following problem.

31 7/9 ÷ 1 62/81 = ____________________

7. (15; minus)

Frame 8. Solve the problems below by addition.

A.	+ 6 + 2 + 9	B.	+ 14 + 12 + 9	C.	− 7 − 5
D.	+ 133 + 291	E.	− 12 − 6 − 92	F.	− 219 − 13 − 191

---

23. (-6)

Frame 24. Since only two numbers can be multiplied together at a time, the product of the first two numbers is multiplied by the third number. Thus, when multiplying

(-3)(-2)(-1), you first multiply (-3) by (-2) for (+6). Then multiply (+6) by (-1) for a final product of (-6).

The product of (-4)(-2)(-2) is equal to ________________________________.

---

41. ($\frac{}{}$

$$\begin{array}{rcr} 4/5 & = & 44/55 \\ -\ 4/11 & = & -\ \underline{20/55} \\ & & 24/55 \end{array}$$

)

Frame 42. Solve 8 3/4 - 4 3/5 ______________________________________.

32. (A, B, C, D, E)

Frame 33. You may ask why "C" is circled. This is a mixed number made up of whole numbers and fractions. It is considered a fraction. Only in proper fractions is the numerator less than the denominator. The 6 2/3 could be rewritten as 20/3. There are 18, 1/3's in 6, plus the additional 2/3 for a total of 20/3. This 20/3 is an improper fraction as "E," 12/7, is. In an improper fraction the numerator is equal to or greater than the denominator.

Write improper, proper, or mixed on the line before each example as it applies.

______________________________ A. 20/21
______________________________ B. 107 1/3
______________________________ C. 15/17
______________________________ D. 201/202
______________________________ E. 19/17

---

50. (18)

Frame 51. Solve the following problems using the four basic arithmetic operations as required.

Solve problems "A" through "C" by addition and subtraction.
A. 1 1/2 + 2 3/4 + 9 1/8 - 6 2/3 =
B. 2 7/8 - 5/6 + 8 5/12 - 7 5/24 =
C. 7 1/10 - 2 2/5 - 9 4/15 + 1 1/3 =

Solve problems "D" through "F" by multiplication.
D. 7/8 x 4 3/4 x (-7 1/3) =
E. 4 1/5 x 9 3/5 x (-1 1/4) =
F. (-2 1/5)(+3 1/9)(-6 3/8) =

Solve problems "G" through "I" by division.
G. 49/72 ÷ 35/18 =
H. 7 2/9 ÷ 3 1/4 =
I. 19 3/18 ÷ 32 1/3 =

Solve problems "J" through "M" as indicated.
J. (7 3/4 - 1 1/2) x 2/3 ÷ 3/8 =
K. 122 1/10 ÷ (1 + 11/100) =
L. (137 2/3 - 2 1/6) x 4/9 - 8/3 =
M. 7/4 ÷ (2/3 + 5/6) - 1/4 + 3 3/8 =

8. (A. +17; B. +35; C. -12; D. +424; E. -110; F. -423)

<u>Frame 9</u>. The third rule for addition is for numbers of unlike signs. The first step is to find the difference between the absolute values.

When adding +6 and -9, the difference of the absolute values is ________.

Return to page 4.

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24. (-16)

<u>Frame 25</u>. Solve the problems below by multiplication.

A. (-4)(+20)(3) =

B. (-3)(-20)(-4) =

C. (6)(12)(-5) =

D. (7)(-2)(-11) =

Return to page 4.

---

42. ($\begin{array}{r} 8\ 3/4 = 8\ 15/20 \\ -\ 4\ 3/5 = \underline{4\ 12/20} \\ 4\ \ 3/20 \end{array}$)

<u>Frame 43</u>. Rules to remember: To add or subtract fractions they must have a least <u>common denominator</u>. To add <u>mixed numbers</u>, add the whole numbers and fractions separately and then unite the sums. To subtract mixed numbers, subtract the fractional parts and then the whole numbers.

Solve 4/7 + 13 - 6 7/8 - 4/3 = _____________________.

Return to page 4.

33. (A. proper; B. mixed; C. proper; D. proper; E. improper)

Frame 34. Multiplying or dividing both numerator and denominator by the same number does not change the value of the fraction.

For example: 5/9 x 4/4 = 20/36.

What is the product or quotient of the following problems?

A. 17/19 x 3/3 =

B. 20/25 ÷ 5/5 =

Return to page 3.

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51. (A. 6 17/24; B. 3 1/4; C. -3 7/30; D. -30 23/48; E. -50 2/5; F. 43 19/30; G. 7/20; H. 2 2/9; I. 115/194; J. 11 1/9; K. 110; L. 57 5/9; M. 4 7/24)

Frame 52. You have now completed the instructional program on basic arithmetic and fractions.

If you had problems completing frame 51, remember these basic rules and attempt frame 51 again, after reviewing the program.

1. Always complete the operations inclosed within parentheses first.

2. Next, complete all division and/or multiplication before doing addition and subtraction.

3. Change all mixed numbers to improper fractions before multiplying or dividing.

4. To add or subtract, reduce all fractions to the least common denominator.

5. Reduce all fractions to the lowest common denominator.

b. Decimals and Percentages

Basic decimals and percentages comprise the second program in this lesson. The ability to perform computations in these areas will aid you to produce correct solutions for mapping operations. By following the instructions in the program, and learning the rules for the problems involved, you should have no trouble.

Frame 1. A decimal is a number that represents a fraction with a denominator that is a power of ten.

In your own words, what is a decimal? ______________________________________

____

____

Turn to page 25, frame 2.

---

11. 25.004)

Frame 12. Thirteen and four tenths would appear as 13.4.

Nine and forty-four hundredths is written: ______________________.

Turn to page 25, frame 13.

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22. (parts per hundred parts)

Frame 23. The symbol for percentage is %. Percent may also be indicated by a fraction or a decimal. Thus 5% = 5/100 equals 1/20 = .05.

The symbol for percentage is _______________________.

Turn to page 25, frame 24.

6. (hundredths)

Frame 7. A decimal is read like this: (example) 35.362 -- "Thirty-five and three hundred sixty-two thousandths."

The 2 in this decimal is in the _______________________ place.

Turn to page 27, frame 8.

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17. (6)

Frame 18. For the third step, if the number to the right of the place you are rounding off is MORE than 5, you add (+1) one to the place and drop the remainder of numbers.

For example: .176

This decimal rounded to tenths becomes .2 because the number to the right of the tenths place (7) is greater than 5. Also note that the 7 and 6 were dropped.

Round .0074 to the nearest hundredth. Circle the correct answer below.

A. .01

B. .007

C. .008

D. .08

Turn to page 27, frame 19.

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28. (.3895)

Frame 29. Now change the following to decimals:

A. 99.42%　　B. .0217%

C. 231.67%　　D. 1.00083%

Turn to page 27, frame 30.

1. (a number representing a fraction with a denominator that is a power of ten)

Frame 2. Fractions having denominators of 10, 100, 1,000, 10,000, etc., are decimal fractions. These denominators are powers of ten.

The fraction 47/100 has a denominator of ___________ and, of course, ten times ten is 100. We say that 100 is the second power of __________________

Turn to page 29, frame 3.

12. (9.44)

Frame 13. Four ten thousandths looks like ____________________________.

Turn to page 29, frame 14.

23. (%)

Frame 24. To change a decimal to percent, move the decimal point two places to the right and add the percent symbol.

For example:
Change .375 to percent.
Move the decimal point two places to the right: 37.5
Add the percent symbol: 37.5%

Change .0275 to percent: _____________________.

Turn to page 29, frame 25.

4A.

Very good! You should be ready for a more difficult problem, so try this one.

Change 12/23 to a decimal with two significant figures. A significant figure is the number of integers in a number, other than the zeros following a decimal point except when a number precedes the decimal point.

For example: $0.000\underbrace{406}_{3}$ **has 3 significant figures**

$\underbrace{70.000123}_{8}$ **has 8 significant figures**

Now solve the problem.

If your answer is-

.0052, turn to page 28, frame 6A.
.52, turn to page 30, frame 8B.

4B.

Wrong! You add only the number of zeros that there are digits in the decimal. There is only one digit in the decimal .7, so there will only be one zero in the fraction. The decimal .679 has three digits so the denominator will have three zeros and looks like: ________________________.

If your answer is-

679/1000, turn to page 38, frame 16A.

679/000, turn to page 30, frame 8C.

7. (thousandths)

Frame 8. When there is a whole number and a decimal, the decimal point is read "AND." When there is only a decimal (no whole number), it is read without using the word "and."

How would "thirty-three thousandths" be written as a decimal?

____

Turn to page 31, frame 9.

---

18. (.01)

Frame 19. When the number to the right is LESS THAN 5, leave the place value as is and DROP THE REMAINDER OF THE NUMBERS.

Round the decimal .7848 to hundredths, and circle your answer.

A. .78 B. .79 C. .785 D. .7800

Turn to page 31, frame 20.

---

29. (A. .9942; B. .000217: C. 2.3167; D. .0100083)

Frame 30. To change a percentage to a fraction FIRST change the percent to a decimal and THEN to a fraction. Reduce the fraction to its lowest terms.

Example: Change 25% to a fraction.
Change to a decimal: 25% = .25
Change to a fraction: .25 = 25/100
Reduce to lowest terms: 25/100 = 1/4
Thus, 25% = 1/4

Change 37.5% to a fraction ____________________________

Turn to page 31, frame 31.

6A.

Wrong. You set your decimal up incorrectly. The problem should have been set up like this: $23\overline{)\,12.000}$

Return to page 26, frame 4A. Do the division again and place the decimal point in the right position: then select the right answer and go to the page indicated.

6B.

7/1 is not correct; 7 = 7/1. Return to page 32 and work the problem again. Then select the correct answer and continue with the program.

6C.

You have misplaced the decimal point. The decimal point ALWAYS goes to the extreme right of the dividend.

Example: $7\overline{)\,12.}$ not $7\overline{)\,1.2}$ from 12/7. Return to page 30, frame 8B. Rework the problem and continue with the program.

6D.

Your division is right, but it is unnecessary to put the 0 at the end of the decimal. Turn to page 26, frame 4A and continue the program.

2. (100; 10 or ten)

Frame 3. All decimals represent fractions and in every case the denominator is a power of ten. The decimal ".1" represents the fraction 1/10. The denominator is a ________________ of ____________________.

Turn to page 34, frame 4.

---

13. (.0004)

Frame 14. Write the numerical form of each of the following word decimals.

A. Sixty-five hundredths

____

B. Sixty and ninety-seven thousandths

____

C. Three hundred and four tenths

____

D. Seventy-five ten thousandths

____

E. Forty-nine thousandths

____

F. Three hundred four thousandths

____

Turn to page 34, frame 15.

---

24. (2.75%)

Frame 25. Change the following decimals to percentages:

A. .4896 B. 1.672
C. .00173 D. .03001
E. 10.002 F. .00097

Turn to page 50, frame 26.

8A.

45/1000 is correct for the first step, but each fraction must be in its lowest terms. Five divides into 45 and 1,000, thus it can be reduced. Go back to page 38, frame 16A and reduce the fraction. Choose the correct answer, and go to the page indicated.

8B.

.52 is correct. You have been changing proper fractions to decimals. Now change an improper fraction to a decimal. It is done in the same manner, but NOW the answer will include a whole number.

For example: 3/2 changed to a decimal is

```
    1.5
2/ 3.0
   2
   1 0
   1 0
     0
```

As you can see, an improper fraction will become a whole number and a decimal (1.5).

Change 12/7 to a decimal: ____________________________.

If your answer is -

.171, turn to page 28, frame 6C.
1.71, turn to page 40, frame 18A.

8C.

You have three zeros but what happened to the 1? The decimal .679 is read "six hundred seventy-nine thousandths," so the denominator becomes 1,000.

Return to page 26, frame 4B and select the correct answer.

8. (.033)

Frame 9. Match the decimal in column 1 with the correct word decimal in column 2, placing the correct letter by the word decimal.

1 (decimal)	2 (word decimal)
A. 4.3	___ six hundreds
B. .006	___ twenty-five and one hundredth
C. 25.01	___ six hundredths
	___ four and three tenths
	___ six thousandths

Turn to page 35, frame 10.

---

19. (A. .78)

Frame 20. The last required place of a decimal fraction is always the number nearest to the unwanted portion of the decimal. The number five is exactly half-way between, so we normally round up. For example, 3.165 to the nearest hundredth would be 3.17.

Round off the following decimals:

To Hundredths:	To Tenths:
41.1145 _______	.6419 _______
.98509 _______	.7500 _______
To Ten Thousandths:	**To Thousandths:**
.29826 _______	.61501 _______
7.11181 _______	7.69653 _______

Turn to page 35, frame 21.

---

30. (3/8)

Frame 31. Convert the following to fractions:

A. 72.5% B. 13.25%
C. 1.678% D. 110.75%

Turn to page 35, frame 32.

18. (Answers to page 40: A. .8; B. 5.2: C. .818: D. 1.3)

You have learned how to change a fraction to a decimal, so let us change a decimal to a fraction. The FIRST thing to do is make the digits of the decimal the NUMERATOR OF THE FRACTION. The denominator of the fraction will have a one (1) followed by the same number of zeros as there are digits in the decimal. For example, the decimal .27 becomes the fraction 27/100. Notice how the number 27 becomes the numerator and the denominator begins with a one and two zeros follow. There were two digits in the decimal, thus there are two zeros in the denominator.

Change .7 to a fraction. ___________________

If your answer is -

7/100, turn to page 26, frame 4B.

7/10, turn to page 38, frame 16A.

7/1, turn to page 28, frame 6B.

1A.

Fine. As you have done on this problem, make sure that any fraction you are working with is in its lowest terms. Change the following decimals to fractions. Remember, REDUCE each to its lowest terms. If you still are not certain of just how to change decimals to fractions, go back to page 32 and review.

Change these to fractions.

A. .7000

B. .009

C. .75

D. .2

Turn to page 53 for answers.

11B.

You neglected the decimal point. You must place decimal points DIRECTLY UNDER EACH OTHER. The sum will have the decimal point carried right down into it from the column being added. Return to page 37, frame 15A and do the problem again. Remember to put the decimal points under each other.

Example:

$$\begin{array}{r} 18.6 \\ .015 \\ 2056.11 \\ 1.1 \\ \hline 2075.825 \end{array}$$

3. (power; ten)

Frame 4. In writing a decimal fraction as a decimal, the denominator is omitted, but the value of the fraction is indicated by placing a point, called a decimal point, to the left of the numerator. The numerator of a decimal always contains as many figures as there are ciphers (zeros) in the denominator of the fraction.

$\frac{53}{100}$ **is written .53**

$\frac{4371}{10000}$ **is written .4371**

$\frac{19}{1000}$ **is written .019**

$\frac{22}{10000}$ **is written .0022**

Note: When there are fewer figures than there are ciphers in the denominator, ciphers are added to the ____________________ of the figure (numerator) to make the required number.

Turn to page 36, frame 5.

---

14. (A. .65; B. 60.097; C. 300.4; D. .0075; E. .049; F. .304)

Frame 15. All fractions can be changed to a decimal by dividing the numerator by the denominator. The decimal may be carried out as many places as the problem indicates.

Example: 7/8 to a decimal is $8\overline{)\,7.000}$ with quotient $.875$

BROKEN INTO STEPS:

1. Divide the numerator (7) by the denominator (8).
2. Place a decimal point to the right of the numerator.
3. Add zeros to the right of the decimal point as needed.
4. Place a decimal point in the quotient DIRECTLY over the decimal point division bracket.
5. Carry out the quotient as far as necessary.

Change 1/2 to a decimal. ____________________

If your answer is -

2.0, turn to page 38, frame 16B.
.5, turn to page 26, frame 4A.
5.0, turn to page 40, frame 18C.

If you are reading this statement you are not following directions. Return to the frame above and follow, VERY CAREFULLY, the directions given there.

9. (A. four and three tenths; B. six thousandths; C. twenty-five and one hundredths)

Frame 10. Now, match column 1 with column 2 in the same manner.

1 (decimal)	2 (word decimal)
A. .25	_____ Two hundredths
B. .002	_____ One and two hundred twenty-two thousandths
C. 20.05	_____ Twenty-five hundredths
D. 1.222	_____ Two thousandths
	_____ Twenty and five hundredths
	_____ Twenty-five hundreds
	_____ One and two hundred twenty-two hundreds

Turn to page 48, frame 11.

---

20. (hundredths: 41.11, .99; tenths: .6, .8; ten thousandths: .2983, 7.1118: thousandths: .615, 7.697)

Frame 21. If you are not having trouble rounding off, proceed to page 37, frame 15A. If you are, and your trouble is mainly knowing the "places," turn to page 36, frame 5, and review. If you do not understand how to round off, review or ask your supervisor for assistance. When you have corrected your trouble, continue to page 37, frame 15A.

NO RESPONSE REQUIRED

---

31. (A. 29/40; B. 53/400; C. 839/50000; D. 1 43/400)

Frame 32. To find the percent of a number, write the percent as a decimal and multiply the number by this decimal.

Example 1: Find 5% of 140.
5% of 140 = .05 x 140 = 7

Example 2: Find 5.2% of 140.
5.2% of 140 = .052 x 140 = 7.28

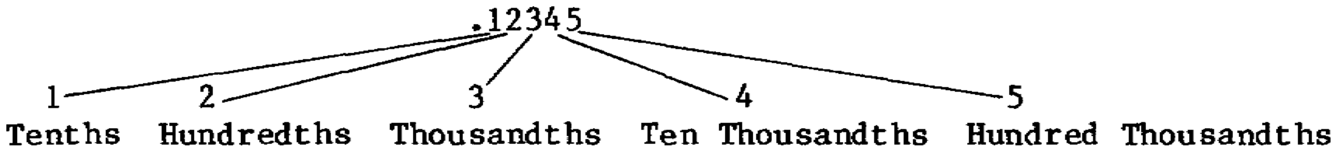
Example 3: Find 150% of 36.
150% of 36 = 1.5 x 36 = 54

What is 61.4% of 2,131? _________________________

Turn to page 48, frame 33.

4. (left or front)

<u>Frame 5</u>. Each digit in a decimal has a place value and is read in a certain way. The places are read as follows:



The 1 is in the tenths place and the 4 is in the __________ place.

Turn to page 49, frame 6.

<u>Frame 16</u>. In many cases, a large cumbersome decimal is not necessary. In those cases where a smaller decimal will do, you may ROUND OFF the decimal. To make a large decimal smaller and easier to use without losing a great deal of accuracy, you will _________ __________ the large decimal.

Turn to page 49, frame 17.

---

26. (28%)

Frame 27. Convert the following fractions to percentages.

A. 3/16 B. 7/10

C. 13/25 D. 2 4/25

E. 8/5 F. 13/50

Turn to page 49, frame 28.

15A.

Adding decimals is much the same as simple whole number addition. The difference is that there is a decimal point to keep in mind. The decimals are put in a column and decimal points are under decimal points (see example). The decimal point is brought down to the sum and the addition is carried on like whole number addition.

Example:

$$\begin{array}{r} 6.3 \\ .01 \\ 22.22 \\ \hline 28.53 \end{array}$$

Add these decimals.

33.79 + .97 + 2.2 = ____________________

If your answer is -

36.96, turn to page 39, frame 17A.

3,498, turn to page 33, frame 11B.

15B.

Wrong. The number to the right of the division sign is always the divisor.

.064 ÷ 3.2 (3.2 is the divisor, not .064)

Set up like this:

$$3.2\overline{)\,0.064}$$

Return to page 47 and select the correct answer.

16A.

Very good. The next thing to remember is to make sure the fraction is in its lowest terms. For example, when changing the decimal .5 to a fraction, it first becomes 5/10. Is this in the lowest terms possible? Of course, the answer is NO! In its lowest terms, it would be 1/2. Always check the fraction and be sure it is in its lowest terms.

Try this one now. Change .045 to a fraction. ________________

If your answer is -

9/200, turn to page 33, frame 11A.

45/1000, turn to page 30, frame 8A.

45/100, turn to page 42, frame 20B.

16B.

In order to change a fraction to a decimal, you divide the numerator by the denominator. You did not do this. In the case of 1/2, the denominator (2) is divided into the numerator (1) like this:

$$\begin{array}{r} .5 \\ 2\overline{)1.0} \\ 1\ 0 \end{array}$$

1/2 changed to a decimal is .5. All fractions are changed to decimals in the same manner.

Change 3/4 to a decimal. ___________________

If your answer is -

.750, turn to page 28, frame 6D.

.75, turn to page 26, frame 4A.

17A.

Right. The main thing to remember is to keep the decimal points lined up under each other. Now let us subtract decimals. The rules are the same as they are in the subtraction of whole numbers. Just as in the addition of decimals, the decimal points must be lined up under each other. You must also remember that the smaller of the numbers must go under the larger.

Solve this problem: 729.75308 - .0077 = ______________________.

If your answer is -

729.75231, turn to page 41, frame 19B.

729.74538, turn to page 43.

23A. (A. 66.42; B. .825.) If your answers are not correct, make the corrections and continue below.

17B.

Now let us divide decimals. The most important factor is that the divisor must be "made" a whole number before division is started. This is done by moving the decimal in the divisor all the way to the right.

Example: $.25\overline{)\quad\quad}$ becomes $25.\overline{)\quad\quad}$. Then move the decimal in the dividend the same number of places to the right.

Example: $.25\overline{)1.25}$ becomes $25.\overline{)125.}$.

Move the decimal point in the following division problem and solve.

$3.3\overline{).66}$

Turn to page 45, frame 23B.

18A.

Right. Now change each of the fractions below to decimals.

A. 4/5

B. 52/10

C. 9/11

D. 13/10

Turn to page 32 to check answers and continue from there.

18B.

No. Move the decimal point in the dividend the same number of places as you did in the divisor.

Example: $3.2\overline{)\,.064}$ becomes $32.\overline{)\,0.64}$

Return to page 47 and select the correct answer.

18C.

You set up your problem correctly but had the decimal in the wrong place. This is what you should have set up for your division:

$2\overline{)\,1.00}$.

Return to page 34, frame 15 and determine the correct answer. Then turn to the correct answer page.

19A.

Right. REMEMBER: The divisor is to the right of the division sign. Solve these problems and show your work.

A. 4.9 ÷ .007 = B. 1179 ÷ 13.1 = C. .02925 ÷ 2.25 =

WORK HERE:

A. B. C.

Go to page 44, frame 22B for answers.

19B.

Remember when you were told that decimal points must go under decimal points? Well, the error you made was because of the decimal placement. A good way to remember the decimal points is put them on the paper first (in a column) and then put the numbers down. Also remember to put the decimal in the answer DIRECTLY under those in the column.

Go back to page 39A and do the problem again.

19C.

No. DO NOT ADD an extra zero to the right of any answer. If you need zeros to make your digit count correct, they must go to the left of the answer. For example:

.2 x .002 will equal .0004, not .4000.

Return to page 44 and select the correct answer.

20A.

Your decimal point should have been placed like this:

```
    3.217
     .471
     3217
   22519
  12868
 1.515207
```

If you had it any other place, return to page 43 and read the rules again.

If you did it correctly, do the following problems by placing the decimal points correctly in the product.

```
A.    .0035          B.    22.222
     x 3.28                  x .11
        280                  22222
        70                  22222
      105                   244442
      11480
```

Turn to page 44, frame 22A.

20B.

There are more than two digits in the decimal .045. Zero is a digit. That makes three digits in this decimal. You should use the same number of zeros as there are digits and make the denominator 1.000.

Return to page 38, frame 16A and select the correct answer.

Right. You are now ready for multiplication. Decimals are multiplied just as whole numbers are, except you have a decimal point to put in the final answer (product). DISREGARD the decimal point in the first two steps. A sample problem is broken into steps to clarify the process.

Problem: .15 x 1.10 =

1. Place the larger number over the smaller.
2. Multiply just as you do in whole numbers.

Example:

```
 1.10
x .15
  550
 110
 1650
```

3. Count the number of digits to the right of the decimal points in the factors of the problem. Example: 1.10 and .15 = 4 digits to the right in this case.

4. Count off 4 places FROM THE RIGHT in the PRODUCT, and place a decimal point. Example: .1650 (product of this problem).

Another problem: 3.1 x 10.21

This problem would be set up and solved like this:

```
 10.21
x  3.1
  1021
 3063
31.651 product
```

Place the decimal point in the product of this problem:

```
  3.217
 x .471
   3217
  22519
 12868
1515207
```

Turn to page 42, frame 20A.

42A. (A. .011480; B. 2.44442)

22A.

Try another problem to make sure that you have the decimal point placement down pat. Solve this one.

$$.55 \times .003 =$$

If your answer is -

.01650, turn to page 41, frame 19C.

.00165, turn to page 45, frame 23A.

41A. (A. 700; B. 90: C. .013)

22B.

Solve these problems: (SHOW WORK)

A. 289.0038 + .992763 = B. .3928 - .02867 =

C. .42 x 3.7 = D. 4.32 ÷ .0036 =

Turn to page 46.

23A.

Very good. Care must be taken with your arithmetic. It is always a good idea to CHECK your multiplication and addition. This is where most errors are made, with few being made on decimal point placement.

Try two more. After completing them, check your arithmetic and decimal placement.

A. 332.1 x .2 =

B. .55 x 1.5 =

Turn to page 39, frame 17B.

23B.

$3.3\overline{)\,.66}$ becomes $33.\overline{)\,6.6}$ by moving the decimal point one place. When the divisor IS a whole number and the dividend a decimal, such as $33\overline{)6.4}$, DO NOT MOVE the decimal-point. Simply place it up in the quotient directly over the decimal point in the dividend, then divide.

For example:

$$\begin{array}{r} .015 \\ 275\overline{)\,4.125} \\ \underline{2\ 75} \\ 1\ 375 \\ \underline{1\ 375} \\ 0 \end{array}$$

Solve $26\overline{)\,7.8}$.

Circle the answer to the problem.

A. 3

B. .3

C. .03

Turn to page 47.

44B.

A.

$$\begin{array}{r} 289.003800 \\ +\ \ .992763 \\ \hline 289.996563 \end{array}$$

B.

$$\begin{array}{r} .39280 \\ -.02867 \\ \hline .36413 \end{array}$$

C.

$$\begin{array}{r} .42 \\ \times\ 3.7 \\ \hline 294 \\ 126 \\ \hline 1.554 \end{array}$$

D.

$$\begin{array}{r} 1200. \\ 36\overline{)\,43200.} \\ \underline{36} \\ 72 \\ \underline{72} \end{array}$$

If you missed any of these problems, go to the part of the program that teaches that type of problem and read the rules again. THEN correct your error(s). The pages that teach each function are listed below:

ADDITION, page 37, frame 15A.
SUBTRACTION, page 39, frame 17A.
MULTIPLICATION, page 43.
DIVISION, page 39, frame 17B.

This completes work on decimals. Go to page 48 and begin work on the program on percentages in frame 22.

$26\overline{)7.8}$ **solved is** $\begin{array}{r} .3 \\ 26\overline{)\,7.8} \end{array}$

If the dividend is a whole number, example: $1.32\overline{)\,25.}$ add zeros and move the decimal point. Example: $1.32\overline{)\,25.00\,.}$ When the decimal has been moved as appropriate, then place a decimal point in the quotient directly over the point in the dividend. For example, divide .1 by 2.5.

Solution: $\begin{array}{r} .04 \\ 25\overline{)\,1.00} \end{array}$

NOTICE HOW THE QUOTIENT IS .04. THIS IS BECAUSE 25 GOES INTO 10 ZERO TIMES, AND INTO 100 FOUR TIMES.

Solve the problem below.

Note: ÷ is the sign for division and the number on the <u>right is always the divisor</u>.

.064 ÷ 3.2 = ____________________

If your answer is -

$\begin{array}{r} 50. \\ .064\overline{)\,3.200} \end{array}$, **turn to page 37, frame 15B.**

$\begin{array}{r} .2 \\ 3.2\overline{)\,.064} \end{array}$, **turn to page 40, frame 18B.**

$\begin{array}{r} .02 \\ 3.2\overline{)\,.064} \end{array}$, **turn to page 41, frame 19A.**

10. (A. twenty-five hundredths; B. two thousandths; C. twenty and five hundredths; D. one and two hundred twenty-two thousandths)

Frame 11. When writing a decimal, FIRST and MOST IMPORTANT, determine the "place" value (tenths, thousandths, etc.). This will give you the number of digits needed to the right of the decimal point.

For example, five and five tenths is written 5.5. (Remember, with a whole number, the decimal is read AND.)

How would twenty-five and four thousandths be written? ____________________

Turn to page 23, frame 12.

Frame 22. The definition of percentage is parts per hundred parts. The comparison is hundred. Thus, 2 percent of a quantity means two parts of every hundred parts of the quantity.

In your own words, define percentage.

____

____

Turn to page 23, frame 23.

---

32. (1308.434)

Frame 33. To find the percent one number is of another, write the problem as a fraction, convert to a decimal, and then write as a percentage.

Example: 3 is what percent of 8?
3/8 = .375
.375 = 37.5%

Thus: 3 is 37.5% of 8.

What percent of 450 is 184.5?

____

Turn to page 50, frame 34.

5. (ten thousandths)

Frame 6. As you probably have noticed, the places to the right of the decimal point all end in "ths." In the decimal 2.46, the 6 is in the _______________ place.

Turn to page 24, frame 7.

---

16. (round off)

Frame 17. Rounding off involves THREE steps. The FIRST TWO include:

1. Determine the PLACE you want to round off to (tenths, hundredths, etc.).

2. Look FIRST at the number (digit) DIRECTLY to the right of that place.

Example: .176

To round to hundredths, first look at the number to the right of the hundredths place. In this case, it is 6.

The first number that you will look at when rounding .265 to tenths is ______________.
(number)

Turn to page 24, frame 18.

---

27. (A. 18.75%; B. 70%; C. 52%: D. 216%: E. 160%: F. 26%)

Frame 28. To change a percentage to a decimal, omit the percent symbol and move the decimal two places to the left.

Example 1: Change 15% to a decimal. Omit the percent symbol: 15% becomes 15. Move the decimal two places to the left: 15 becomes .15. Thus, 15% = .15.

Example 2: Change 110% to a decimal. 110% becomes 110, 110 becomes 1.10. Thus, 110% = 1.10.

Change 38.95% to a decimal.

____

Turn to page 24, frame 29.

25. (A. 48.96%; B. 167.2%; C. .173%; D. 3.001%: E. 1000.2%; F. .097%)

Frame 26. When converting a fraction to percent, divide the numerator by the denominator and convert to a decimal. Then convert the decimal to a percentage.

Example: Change the fraction 5/8 to percent. Divide the numerator by the denominator: $5 \div 8 = .625$. Convert the decimal to percent: $.625 = 62.5\%$. Thus, $5/8 = 62.5\%$.

What is 7/25 in percent?

____

Turn to page 36, frame 27.

---

33. (41%)

Frame 34. Relative error is the accuracy of measurement expressed as percent of the total measurement. The limit of error must be established first. It is the difference between the true value and the measured value. Assume that the reading on a set of scales, to the nearest tenth of a gram, is 2.2 grams. If the true weight is 2.15 grams, the limit of error is the difference between 2.15 and 2.2, or .05 grams.

Relative error = $\frac{\text{limit of error}}{\text{measured value}}$, expresses the result as percent.

In this case, relative error = $\frac{.05}{2.2}$ **= 2.27% or 2.3%**

NO RESPONSE REQUIRED

Turn to page 52. frame 35.

35.

1. $\dfrac{\$8.04}{\$100.50} = 10050\overline{)804.00}^{\,.08} = 8\%$

$24 \times \$8.04 = \$192.96$

2. $37.55\overline{)150.20}^{\,4.}$ = 4 hours

$\underline{150\ 20}$

3. A. 3/24 = 1/8 = 12.5%

B. 7/24 = 29.17%

C. 15/24 = 5/8 = 62.5%

4. and 5. If you solved 4 and 5 correctly, congratulations. If not, don't worry about it. They introduce you to your next programmed instruction on ratios and proportions.

For example 4. 25% = 1/4, then 4 times as much concrete must be poured for the total job. So: 4 x 360 = 1,440 cubic yards.

For example 5. 80% = 4/5, or 4/5 of the total strength is 136. Then full strength is 170 men.

$.8\overline{)1360} = 170$

Turn to page 55.

Frame 35. Solve the following problems.

1. A soldier has $8.04 deducted from his monthly pay of $100.50. What percent is deducted, and how much will be deducted in 24 months?

2. A truck averages 37.55 miles per hour. How long will it take to travel 150.2 miles?

3. Your company is building 24 miles of road. What percent completed are you when:

   A. 3 miles are completed?

   B. 7 miles are completed?

   C. 15 miles are completed?

4. A construction company has paved 360 cubic yards of concrete. If this is 25% of the total amount to be poured, how many cubic yards are required for the complete job?

5. A company contains 136 men. If this is 80% of the TOE strength, what is the total strength of the company?

Turn to page 51.

11A. (A. 7/10; B. 9/1000; C. 3/4; D. 1/5)

Turn to page 36, frame 16.

c. Basic Algebra

Basic Algebra is the third program in this lesson. Ability to accurately perform computations in this area will aid you in producing correct solutions for mapping operations. By following the instructions in the program and learning the rules for the problems involved, you should have no trouble.

<u>Frame 1</u>. Algebra is that part of mathematics which employs letters in reasoning about numbers, either to find their general properties or to find the value of an unknown from its relation to known numbers.

In algebra, _________________ are used in reasoning about numbers.

Turn to page 58, frame 2.

11. (monomial; binomial: polynomial)

Frame 12. The absolute value of a number is its value without regard to the sign before it.

Example: The numbers +7 and -7 have the same absolute value, 7.

The absolute value of -3 and +3 is ___________________.

Turn to page 59, frame 13.

1. (letters)

Frame 2. The chief thing that makes algebra different from arithmetic is the use of letters instead of figures to represent numbers and the use of these letters to form expressions and equations.

Instead of using figures to represent numbers, ___________ are used. These ___________ are then used to form ____ and ______________________________________.

Turn to page 60.

12. (3)

<u>Frame 13</u>. When two or more terms form an expression that is to be subjected to operations such as multiplication or division, they are inclosed in parentheses ( ), brackets [ ], or braces { }. These are called symbols of aggregation.

Example: If 4X is to be multiplied by 2a + b, the expression is written 4X(2a + b).

The parentheses show us that we are multiplying the expression 2a - b, as a whole, by the term 4X. The expression (a)[4-b(a-b)] indicates that the difference between a - b is to be multiplied by b and the product of this subtracted from 4 before it is multiplied by a.

The three symbols of aggregation are _______________, _______________, and _______________.

Turn to page 61.

2. (letters; letters, expressions, equations)

<u>Frame 3</u>. When figures are used to express a mathematical situation, the expressions obtained refer to specific cases.

Figures limit the expressions obtained to _______________ ______________.

Turn to page 62.

13. (parentheses, brackets, braces)

Frame 14. When the root of a quantity is extracted, the sign $\sqrt{}$, called the radical sign, is used together with a small figure known as the index of the root.

Some of the radical signs used are as follows:

Square root $\sqrt{}$

Cube root $\sqrt[3]{}$

Any root $\sqrt[N]{}$

Any number can be substituted for N.

The radical sign that shows the cube root of a number is ______________.

The square root is _________, and to show any root of a number is _________.

Turn to page 63.

3. (specific cases)

<u>Frame 4</u>. The basic concept which we shall add to our previous knowledge of math is the idea of a general number; that is, the representation of numbers by letters.

Example: We say that a room is x feet long and that x may stand for any number. If we are speaking of a particular room and measure it to be 10 feet long, then x would equal 10; however, for a different room x may have a different value.

The representation of numbers by letters is accomplished by using the concept of a _______________ ________________.

Turn to page 64.

14. $(\sqrt[3]{\quad}, \sqrt{\quad}, \sqrt[N]{\quad})$

Frame 15. In algebraic addition there are three cases which must be taken into account. They include:

A. Positive number plus positive number

B. Positive number plus negative number

C. Negative number plus negative number

Examples: A. To add two or more positive numbers, find the sum of their absolute values and prefix to this sum the positive sign. Hence, add +7Y and +6Y; the product equals +13Y.

B. To add a positive number and a negative number, find the difference of their absolute values and prefix the sign of the larger number to the result. Hence, add -9ax to +3ax: the product equals -6ax.

C. To add two or more negative numbers, find the sum of their absolute values and prefix to their sum the minus sign. Hence, add -9x to -6x: the product equals -15x.

Add the following problems.

$+ 25xy$	$- 37a$	$- 43bc$	$+ 20b$
$\underline{+ 18xy}$	$\underline{+ 22a}$	$\underline{- 37bc}$	$\underline{- 50b}$

Turn to page 65.

4. (general number)-

<u>Frame 5</u>. When two or more quantities are multiplied together, each quantity is called a factor of the product.

Example: If 4, 6, and 8 are multiplied together the product is 192; then 4, 6, and 8 are factors of 192, but since 4 x 6 is 24 and 24 x 8 is 192, then 24 and 8 are also factors of 192.

If the product of 3 x 4 x 6 is 72, the factors of 72 are _____, _____, and _____.

Turn to page 66.

15. (+43xy; -15a; -80bc; -30b)

Frame 16. One general rule is sufficient to cover all cases of algebraic subtraction. Change the sign of the subtrahend, and then add the altered subtrahend to the minuend, using the rules for algebraic addition.

In the above rule, the subtrahend is the quantity to be subtracted and the minuend is the quantity that it is to be subtracted from.

Example: To subtract -4ab from +8ab, change the sign of the subtrahend (-4ab), and then add to the minuend (+8ab); the algebraic sum equals +12ab.

Solve, by subtraction, the following:

+3a from +5a.

-2x from +3x.

Turn to page 67.

d. (3, 4, and 6)

Frame 6. In any expression that represents a product, any one of the factors, or the product of any two or more of them, may be regarded as the coefficient of the remaining part of the expression.

Example: If the quantity 7abc is considered, 7 is the numerical coefficient of abc, 7a is the algebraic coefficient of bc, and 7ab is the algebraic coefficient of c.

If the quantity 5xy is considered, 5 is the ______________ of xy and 5x is the _______________ of y.

Turn to page 68.

16. (+2a; +5x)

<u>Frame 17</u>. In multiplication of algebraic terms, the product of two numbers having like signs is a positive number and the product of two numbers having unlike signs is a negative number.

Examples: Multiply +8x by +4x: it can be written as (8x) (4x). The algebraic product equals $32x^2$.
The product of (-8x) (4x) = $-32x^2$.

Find the product of the following:

(2a) (6a).

(-3b) (3b).

Turn to page 69.

6. (numerical coefficient: algebraic coefficient)

Frame 7. An exponent is any number or algebraic expression written at the right of, and above, another number or algebraic expression to show how many times the latter is to be taken as a factor.

Example: If 4 is multiplied by itself, we say we have squared 4 (written as 4^2). If a is multiplied by itself, we express it as a^2.

The exponent of any number or expression will be placed at the __________ of, and __________, that number or expression.

Turn to page 70.

17. ($12a^2$; $-9b^2$)

Frame 18. In division of algebraic terms, the quotient of two numbers having like signs is positive and the quotient of two numbers having unlike signs is negative.

Examples: Find the quotient of $8x \div 2$.
(Like signs) $8x \div 2 = 4x$

Find the quotient of $8x \div -2$.
(Unlike signs) $8x \div -2 = -4x$

Find the quotient of the following:

$32x \div 4$.

$32x \div -4$.

Turn to page 71.

7. (right, above)

Frame 8. The number whose power is to be found is called the base number.

Example: In the expression a^3, a is the base number and 3 is the power of the base number that is desired.

In the expression X^2, X is the _______________ and 2 is the _______________ of the base number.

Turn to page 72.

18. (8x; -8x)

Frame 19. An algebraic equation is a statement of equality between two quantities or operations. Equations are a very convenient means of expressing the relationship between known and unknown quantities. An equation of this type is called a formula.

A formula can also be referred to as an ________________________________ _________________________.

Turn to page 73.

8. (base number, power)

<u>Frame 9</u>. When multiplying quantities having the same base numbers, their exponents are added. When dividing quantities having the same base numbers, their exponents are subtracted.

Example: If we were to divide a^4 by a^2, we would subtract 2 from 4, giving us a final result of a^2. If, however, we had been multiplying a^4 by a^2, we would have obtained a result of a^6.

The exponents are __________ when dividing quantities which have the same base numbers, and _________________ when multiplying quantities having the same base numbers.

Turn to page 74.

19. (algebraic equation)

Frame 20. The quantity that, when substituted for the unknown quantity, reduces an equation to an equality is said to satisfy that equation.

Example: x - 9 - 11 is satisfied when the value 2 is substituted for the unknown x.

Satisfy the following equations.

9 + x= 15 x = _____________

x - 15 = 12 x = _____________

Turn to page 75.

9. (subtracted, added)

Frame 10. An algebraic expression may consist of parts which are separated by the + and - signs; these parts with signs immediately preceding them are called terms.

Example: The expression 3X + 4Y + Z is separated by the plus or minus sign into three parts, +3X, +4Y, +Z. These parts are the terms in the expression.

If an algebraic expression is separated into parts by the + or the - signs, these parts are called the _________________ of the expression.

Turn to page 76.

20. (6; 27)

Frame 21. The form of an equation may be changed, when solving an equation, but the change must be such that the sides remain equal to each other after the change. The same change must be made in both sides so they remain equal. The change in the form of an equation in this manner is called transformation. The four commonly used ways of transformation are as follows:

1. By adding the same quantity to both sides of the equation.

Example:
$$\begin{array}{r} 2x + 10 = 16 \\ 5 = 5 \\ \hline 2x + 15 = 21 \end{array}$$

2. By subtracting the same quantity from both sides of the equation.

Example:
$$\begin{array}{r} 2x + 10 = 16 \\ - 5 = -5 \\ \hline 2x + 5 = 11 \end{array}$$

3. By multiplying both sides of an equation by the same quantity, or by raising both to the same power.

Example:
$$\begin{aligned} 2x + 10 &= 16 \\ (2x + 10)^2 &= (16)^2 \\ 4x^2 + 40x + 100 &= 256 \\ (2)\ (2x + 10) &= (2)\ (16) \\ 4x + 20 &= 32 \end{aligned}$$

4. By dividing both sides of an equation by the same quantity, or by extracting the same root of both sides.

Example: $\frac{2x + 10}{2} = \frac{16}{2}$ or $x + 5 = 8$

The value of each side of the equation is changed by any form of ____________________, but the sides still remain equal and the value of the unknown is not altered.

Turn to page 77.

10. (terms)

Frame 11. If an expression contains only one term it is said to be a MONOMIAL: if it has two terms it is a BINOMINAL, and if it has many terms it is a POLYNOMIAL.

Example: The expression 5X has only one term. Therefore, it is a monomial expression; if however, the expression had two terms, 5X + 5Y, it would be a binomial expression; and if it had more than two terms, 5X + 5Y + 5A, it would be a polynomial expression.

A one term expression is said to be ______________, an expression with two terms is a ___________________ expression, and an expression with many terms is a ___________________ expression.

Go back to page 57 and continue with frame 12.

21. (transformation)

Frame 22. Transposition is the process of taking a term from one side of an equation and placing it in the other side of the equation with the sign changed. It is equivalent to adding the same quantity to, or subtracting the same quantity from, both sides of the equation.

Example: $6x + 4 = 2x + 3$

The 2x can be brought to the left side of the equation by dropping it from the right side and writing it in the left side with the sign changed. Now the equation reads:

$6x - 2x + 4 = 3$ or $4x + 4 = 3$.

Transpose 15x in the following equation:

$23x - 4 = 15x + 4$. ______________________

Turn to page 78.

22. ($23x - 15x - 4 = +4$ or $8x - 4 = +4$)

Frame 23. The following is a precise statement of what to do in solving the simple equation:

1. Transpose all the terms containing the unknown to one side of the equation.

2. Transpose all the terms not containing the unknown to the other side of the equation.

3. Divide both sides of the equation by the coefficient of the unknown.

After transposing all terms containing the unknown to one side and all terms not containing the unknown to the other side, both sides are then __________ by the coefficient of the unknown.

Turn to page 79.

23. (divided)

d. Trigonometry

Trigonometry is the fourth program in this lesson. Ability to accurately perform computations in this area will aid you in producing correct solutions for mapping operations. By following the instructions in the program, and learning the rules for the problems involved, you should have no trouble.

Answers to frames in this section appear on the following page.

INSTRUCTIONS

Remember that you continue through each frame in numerical order. You will probably get along all right on your own, but in case you need help, ask your supervisor for assistance.

The sides of a plane triangle are so related that any three given parts, at least one of them a side, determine the shape and size of the triangle.

Geometry shows us how, from three such parts, to CONSTRUCT the triangle.

TRIGONOMETRY shows us how to compute the unknown parts of a triangle from the numerical values of the given parts.

Geometry shows a general way that the sides and angles of a triangle are mutually dependent.

Trigonometry starts by showing the exact nature of this dependence in the RIGHT TRIANGLE, and for this purpose employs the RATIOS OF THE SIDES.

Frame 1. Complete the following sentences.

A. The shape of any triangle is determined by any __________ given parts, at least one being a __________.

B. __________ shows us how to construct the triangle.

C. Trigonometry teaches us how to __________ for the unknown parts of a triangle.

D. To show the nature of the mutual dependency of sides and angles in a right triangle, trigonometry uses the __________ of the __________.

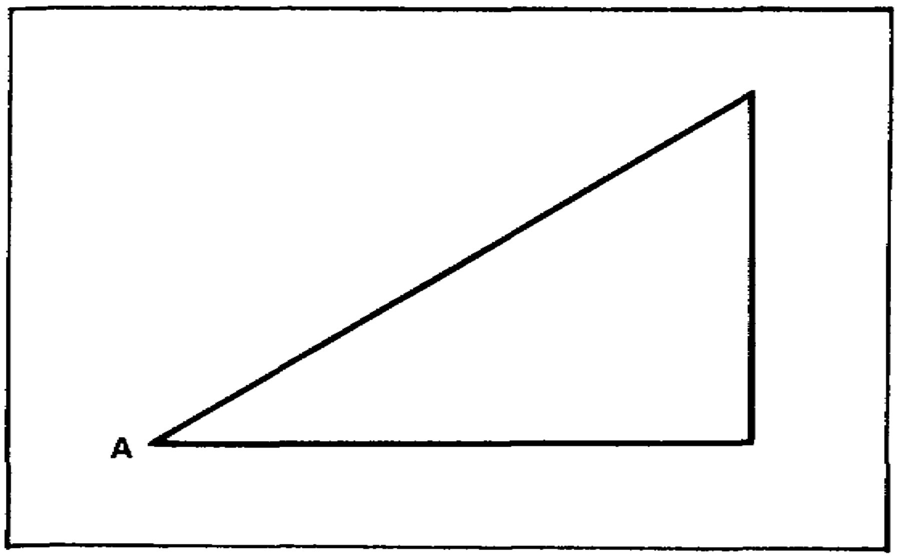
1. (A. three, side; B. geometry; C. compute; D. ratios, sides)

Frame 2. In order to keep the labeling of the various parts of triangles consistent, we label the angles in capital letters (A, B, C) and the sides in lower case letters to coincide with their opposite angles (a, b, c).

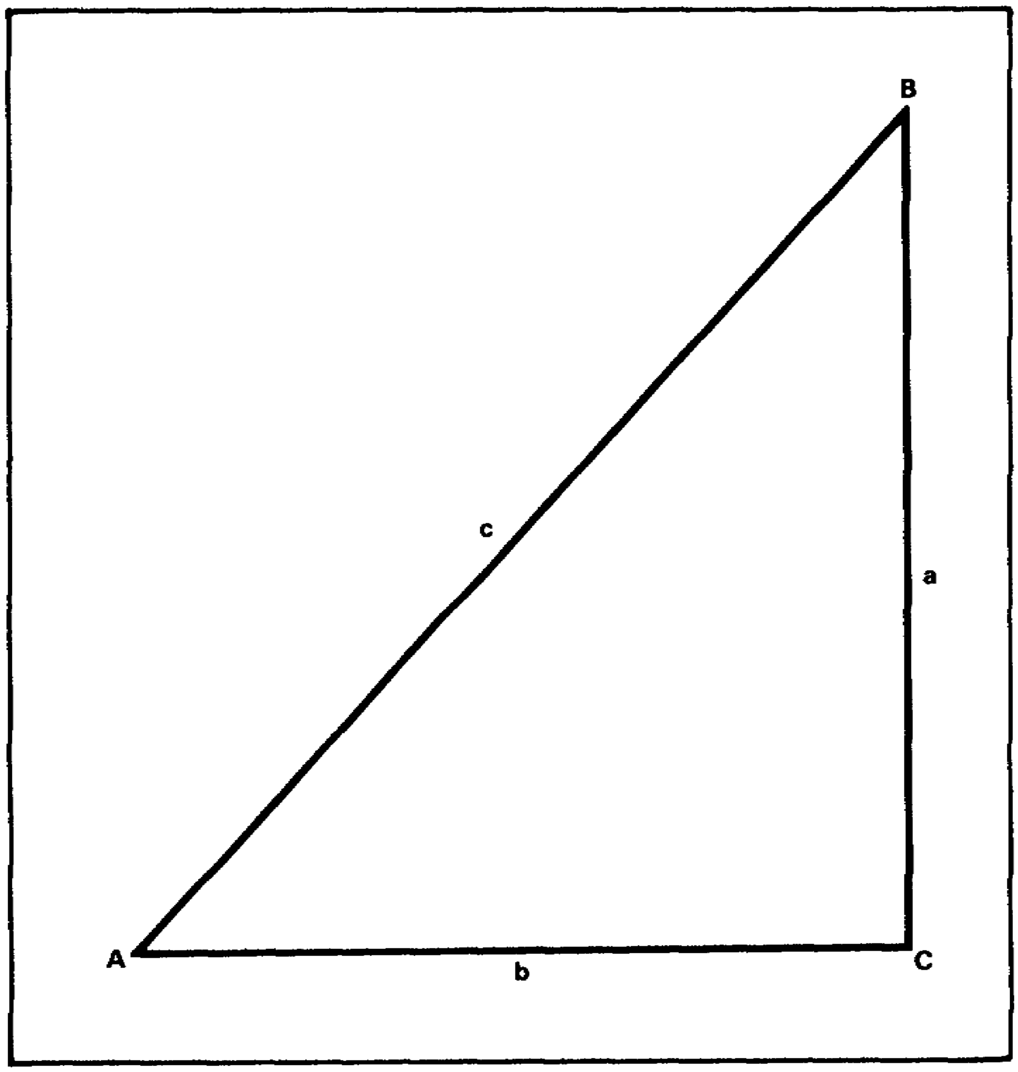
Normally we label the right angle as C making the side opposite the right angle c.

Also, in right triangles the side opposite the right angle is called the hypotenuse.

Given right triangle ABC, label the sides and angles.



Answer for frame 2 shown below.



Frame 3. The angle opposite side b is _____________.

3. (B)

Frame 4. The Pythagorean Theorem states that the sum of the squares on the sides of a right triangle is equal to the square on the hypotenuse.

Using our established method of lettering the parts of a right triangle we can state that c^2 = _________

and c = _________

4. $(c^2 = a^2 + b^2$

$c = \sqrt{a^2 + b^2})$

Frame 5. Using the same theorem we can state that b = __________

and a = __________.

5. $(b = \sqrt{c^2 - a^2} \quad , \quad a = \sqrt{c^2 - b^2})$

Frame 6. In right triangle ABC: $a = 6$, $b = 8$.

What is the value of c? ________________________

6. (10)

Frame 7. In right triangle ABC: $c = 10$, $b = 6$.

What is the value of a? ________________________

7. (8)

LESSON I SELF-TEST

Addition:

A. 8753 + 798 =

B. 2895 + 25 + 489 =

C. 2384 + 784 + 2989 + 3001 + 14 + 6 =

D. 4186 + 9001 + 8368 + 02 =

E. 195003 + 28443 + 268 =

Subtraction:

A. 333897 - 298777 =

B. 26798 - 23489 =

C. 38765 - 498456 =

D. 492345 - 498456 =

E. 501010 - 490909 =

Addition of Common Fractions:

A. 1/4 + 1/2 + 3/8 + 3/4 =

B. 5/8 + 3/8 + 3/32 + 15/16 =

C. 3/4 + 1/2 + 4/8 =

D. 3/11 + 7/11 + 21/22 + 3/4 =

E. 12 1/2 + 12 7/8 + 3 3/4 + 11 31/32 =

Subtraction of Common Fractions: Numbers without - signs are positive numbers:

A. 12 7/8 + 4 7/8 - 10 3/4 - 5 7/8 =

B. 11 1/2 - 8 3/4 - 9 5/8 - 2 7/8 =

C. 21 1/5 - 8 5/10 - 2 10/25 - 1 5/25 =

D. - 7/8 - 4 7/8 - 10 3/4 - 5 7/8 =

E. - 12 7/8 - 3 3/4 - 11 31/32 - 12 1/2 =

Addition of Decimal Fractions:

A. 127.321 + 14.40 + 160.3 + 427.3378 + 0.01 =

B. 24.8 + 26.8325 + 150 + 273.986 =

C. 2.003 + 228.2 + 286.86 + 0.009 =

D. 3807.52 + 39.6878 + 2.23 =

E. 784.01 + .09 + 1.10 + 0.80 =

Subtraction:

A. 7847.4951 - 279.02 =

B. 986.986 - 23.2 =

C. 2495.778 - 0.0009 =

D. 538.444 - 500.04 =

E. 287.876 - 187.765 =

Multiplication:

A. 7/8 x 3/4 =

B. 51/64 x 29/32 x 7/8 x 5/8 =

C. 5/8 x 7/8 x 1/2 x 2/21 =

D. (3/4 x 4/8 x 1/2) - 1/2 =

E. 5 1/2 x 10 3/4 x 4 7/8 =

Common Fractions to Decimal Fractions:

A. 7/8

B. 3/10, 3/100, 3/1000

C. 184 5/8, 127 2/3

D. 15/16, 3/4, 2/9, 10/11

E. 4/5, 1/5, 2/5, 3/5

Decimal Fractions to Common Fractions (Proper or Improper):

A. 16.875, 3.75, 1.625

B. 0.50, 0.6667, 0.5

C. 1.678, 2.556, 3.125

D. 14.422, 128.333, 2.89

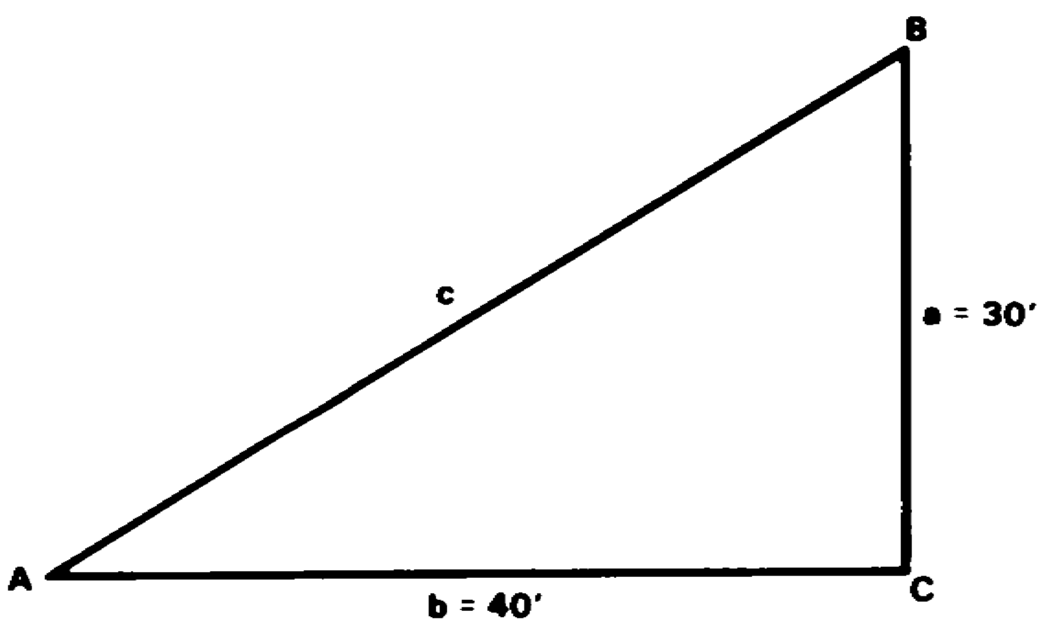
E. 24.675, 21.321, 14.123

Algebra: Solve to find X

A. 6X + 7 = -13 + X

B. 2X - 15 = X - 2

Trigonometry:



$$c = \sqrt{a^2 + b^2}$$

Given a = 30° and b = 40°.

Find c using the formula.

LESSON I SELF-TEST ANSWER SHEET

Addition:

A. 9,551

B. 3,409

C. 9,178

D. 21,557

E. 223,714

Subtraction:

A. 35,120

B. 3,309

C. -459,691

D. -6,111

E. 10,101

Addition of Common Fractions:

A. 1 7/8

B. 2 1/32

C. 1 3/4

D. 2 27/44

E. 41 3/32

Subtraction of Common Fractions:

A. 1 1/8

B. -9 3/4

C. 9 1/10

D. -22 3/8

E. -41 3/32

Addition of Decimal Fractions:

A. 729.3688

B. 475.6185

C. 517.072

D. 3849.4378

E. 786

Subtraction:

A. 7568.4751

B. 963.786

C. 2495.7771

D. 38.404

F. 100.111

Multiplication:

A. 21/32

B. $\frac{51765}{131072}$

C. 5/192

D. -5/16

E. 288 15/64

Common Fractions to Decimal Fractions:

A. .875

B. .3, .03, .003

C. 184.625, 127.667

D. .9375, .75, .222, .9091

E. .8, .2, .4, .6

Decimal Fractions to Common Fractions:

A. 16 7/8, 3 3/4, 1 5/8

B. 1/2, 2/3, 1/2

C. 1 339/500, 2 139/250, 3 1/8

D. 14 211/500, 128 1/3, 2 89/100

E. 24 27/40, 21 321/1000, 14 123/1000

Algebra:

A. X = -4

B. X = 13

Trigonometry:

50'

LESSON II

METRIC SYSTEM

OBJECTIVE:	At the end of this lesson you will be able to solve basic mapping problems that make use of the metric system.
TASK:	Related Task Numbers. 051-257-1203 Construct Map Grids 051-257-1204 Construct Map Projections 051-257-1205 Plot Geodetic Control 051-257-2236 Compute Enlargement/Reduction Factors 051-257-2238 Construct Controlled Photomosaics
CONDITIONS:	You will have this subcourse booklet and will work on your own.
STANDARDS:	You must correctly answer the questions in the written performance test with 75 percent accuracy.
CREDIT HOURS:	1
REFERENCES:	None

INSTRUCTIONAL CONTENT

INTRODUCTION

The only two major countries still using the English system of measurement are the United States and Canada. They, too, are slowly converting to the metric system. When working in foreign countries, your mapping project, in order to tie in with local mapping projects, must be in the metric system. Therefore, you must know and be able to convert from the English to metric system. You should also get acquainted at this time with the meaning of the metric prefixes listed below.

milli (m) means 1/1000
centi (c) means 1/100
deci (d) means 1/10
deka (da) means 10
hecto (h) means 100
kilo (k) means 1.000

(Thus, mm denotes millimeter, cm = centimeter, km = kilometer, cl = centiliter, dl = deciliter, etc.)

In length, we have the meter (m) as the basic unit and we know that 10 m = 1 dam, 10 dam = 1 hm, and 10 hm = 1 km. So we see that it takes 1,000 m per km. Also, 1/10 m = 1 dm, 1/10 dm = 1 cm, and 1/10 cm = 1 mm.

Before taking the self-test, you should work through the programmed lesson.

LEVEL A

PART I

METRIC SYSTEM

Reminder: In this space on the following pages you will find verification of your response(s) for the previous frame.

Frame 1. The three common units of measure used in the metric system include:

The METER (length), the GRAM (weight), and the LITER (volume). These units of measure are illustrated on page 106.

Three common metric units of measure are the __________ (length), the __________ (weight), and the __________ (volume).

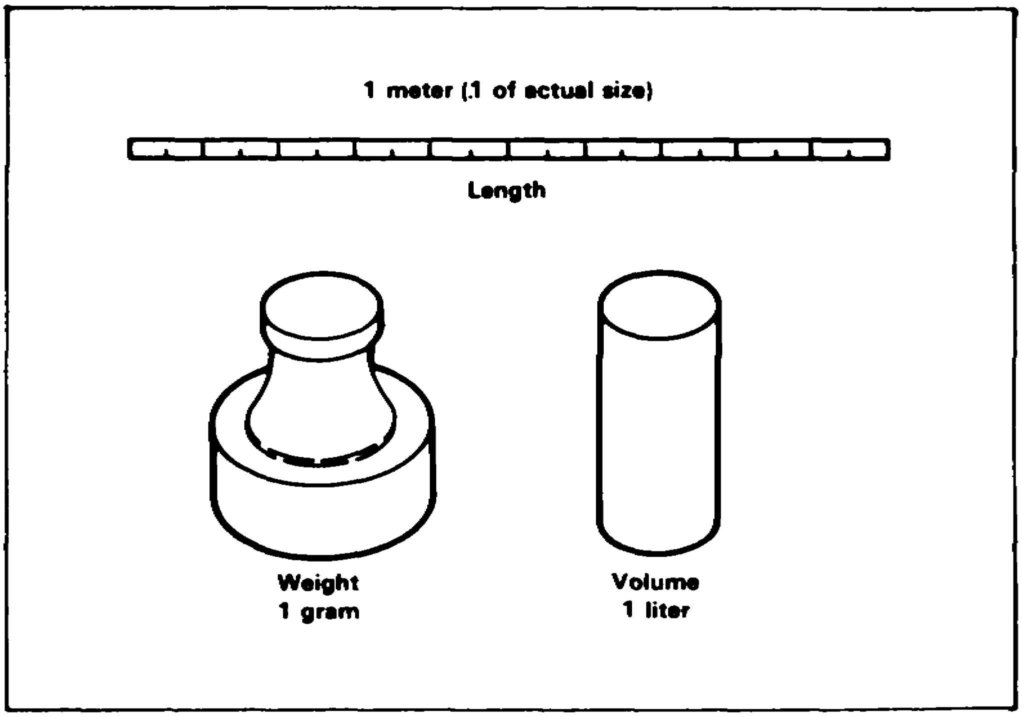
---

14. (km; hm)

LEVEL B

Frame 15. Twenty-five centimeters is written with the number first, followed by the abbreviation: 25 cm.

29 millimeters is written ____________________.
32 decimeters is written _____________________.


1 meter (.1 of actual size)
Length
Weight
1 gram
Volume
1 liter

1. (meter, gram, liter)

<u>Frame 2</u>. These three units of the metric system are abbreviated with a lower case letter <u>m</u> for meter (length), <u>g</u> for gram (weight) and <u>l</u> for liter (volume).

The abbreviations for the three metric units of volume, length, and weight are _____, _____, and _____.

---

15. (29 mm: 32 dm)

Frame 16. The abbreviation used for 10 decimeters is 10 dm.

The abbreviation used for 10 centimeters is 10 __________.
The abbreviation used for 10 millimeters is 10 __________.

2. (l, m, and g)

Frame 3. A draftsman will very seldom be dealing with the gram, which is used for weights, or the liter, which is used for volume. You will, however, be continuously involved in measurements of length. The METER is the basic unit of length in the METRIC SYSTEM.

The meter is used for measurements involving ______________________.

16. (cm; mm)

Frame 17. Whole numbers (Greek prefixes) such as a dekameter, hectometer. and kilometer are multiples of 10.

Examples:

A dekameter = 10 meters.
A hectometer = 100 meters.

A kilometer = _________ meters.

3. (length)

Frame 4. The common subdivisions of the meter, as well as other metric units, are designated by the use of PREFIXES.

Examples:

deka<u>meter</u>	deci<u>meter</u>
hecto<u>meter</u>	centi<u>meter</u>
kilo<u>meter</u>	milli<u>meter</u>

____________________ are used to name the subdivisions of the meter.

---

17. (1.000)

Frame 18. You should become familiar with the following Greek Prefixes: kilo, hecto, and deka.

When a prefix is used with the basic word METER (length), it will appear as in the following example: kilometer = km.

We now understand that the abbreviation km represents kilometer, hm represents ____________, and dam represents _________________.

Kilo	Hecto	Deka	Meter	Deci	Centi	Milli
1,000	100	10	1	.1	.01	.001

4. (prefixes)

<u>Frame 5</u>. A METER, the basic unit of length, is the common word used to identify all measures of LENGTH.

The KILOMETER and MILLIMETER are identified by their common word, meter, to be measures of _________________________.

---

18. (hectometer, dekameter)

Frame 19. Latin prefixes that you will become familiar with include: deci, centi, and milli.

When prefixes are used with the basic word METER (length), they will appear as in the following example: decimeter = dm.

We now understand that the abbreviation dm represents decimeter, cm represents __________ and mm represents __________.

5. (length)

<u>Frame 6</u>. The Greek prefixes DEKA, HECTO, and KILO represent <u>whole numbers</u> which are multiples of <u>10</u>.

Examples:

deka = 10 (ten)
hecto = 100 (hundred)
kilo = 1.000 (thousand)

The basic unit of length is the METER.

A dekameter = __________ meters.
A hectometer = _________ meters.
A kilometer = __________ meters.

---

19. (centimeter; millimeter)

Frame 20. Decimal fractions (Latin prefixes) such as decimeter, centimeter, and millimeter are subdivisions of 10.

Examples:

A decimeter = .1 of a meter.
A centimeter = .01 of a meter.

A millimeter = .__________ of a meter.

6. (10; 100: 1,000)

Frame 7. We have learned that -

A dekameter is equal to 10 meters.
A hectometer is equal to 100 meters.
A kilometer is equal to 1,000 meters.

Deka, hecto and kilo represent ____________ numbers which are multiples of ___________.

---

20. (.001)

Frame 21. The metric system is in units of ten, hence:

A kilometer = 1,000 meters.
A hectometer = 100 meters.
A dekameter = 10 meters.

The basic unit of length = 1 meter.

10,000 meters = 10 kilometers; 6,000 meters = ____________ kilometers.

7. (whole, 10)

Frame 8. The word METER (the basic unit of measure) is preceded by the Greek prefixes deka, hecto, and kilo to form -

A kilometer = _____________ meters.
A hectometer = ____________ meters.
A dekameter = _____________ meters.

---

21. (6)

Frame 22. We have also learned that:

A millimeter = .001 of a meter.
A centimeter = .01 of a meter.
A decimeter = .1 of a meter.

Ten-thousand millimeters = 10 meters; six meters = ____________ millimeters.

8. (1,000; 100: 10)

Frame 9. The Latin prefixes DECI, CENTI, and MILLI represent decimal fractions, which are recognized as <u>decimal multiples of 10</u>.

Examples:

deci = .1 (tenth)
centi = .01 (hundredth)
milli = .001 (thousandth)

The basic unit of measure is the METER.

A decimeter = .______________ of a meter.
A centimeter = .______________ of a meter.
A millimeter = .______________ of a meter.

---

22. (6,000)

<u>Frame 23</u>. We know that -

A kilometer	= 1.000 meters.
A hectometer	= 100 meters.
A dekameter	= 10 meters.
A meter	= The basic unit of length.
A decimeter	= .1 meter.
A centimeter	= .01 meter.
A millimeter	= .001 meter.

.001 meter = A ___________________.
10 meters = A ___________________.
.1 meter = A ___________________.

9. (.1; .01; .001)

Frame 10. We know that -

The meter is the basic unit (meter = 1).
The decimeter is a decimal multiple of a meter (decimeter = .1).
The centimeter = .01 and a millimeter = .001 of a meter.

Deci, centi and milli represent decimal ____________ which are recognized as _________________ of 10.

---

23. (millimeter; dekameter; decimeter)

Frame 24. Complete the following:

30,000 meters = __________________ km.
12,000 millimeters = ___________________ meters.

10. (fractions, decimal multiples)

Frame 11. The basic unit of length is the _______________.

A decimeter = .________ of a meter.
A dekameter = _________ meters.
A centimeter = .________ of a meter.
A hectometer = _________ meters.
A millimeter = .________ of a meter.
A kilometer = _________ meters.

---

24. (30; 12)

Frame 25. The basic unit of length is the meter (m = 1).

Example:

1,709.5194 m. When changing meters to decimeters (from a larger to a smaller unit) move the decimal point ONE PLACE TO THE RIGHT.

Therefore: 1,709.5194 m = 17,095.194 dm.

17,095.194 dm = __________________ cm.
17,095.2 cm = __________________ mm.

11. (.1; 10; .01; 100; .001; 1,000)

<u>Frame 12</u>. Abbreviated Greek prefixes representing whole multiples of 10 are written as in the following example:

(Note: See page 128 for list of some units and symbols.)

<u>Unit</u>	<u>Symbol</u>
dekameter	dam

Write the abbreviation for the following:

kilometer = ____________________.
hectometer = ____________________.

---

25. (170,951.94; 170,952)

<u>Frame 26</u>. The basic unit of length is the meter (m = 1).

Example:

1,709.5194 m.

To change m to dam (1 m = 0.1 dam) (from smaller to larger unit) move the decimal point ONE PLACE TO THE LEFT.

Therefore: 1,709.5194 m = 170.95194 dam.

To change 170.95194 dam to hectometers (1 hm = 100 m) move the decimal point ___________ place(s) to the ______________.

Solve the following problems.

170.95194 dam = ___________________ hm.
17.095194 hm = ___________________ km.

SOME UNITS AND THEIR SYMBOLS

UNIT	SYMBOL	UNIT	SYMBOL
acre	acre	kiloliter	kl
board foot	fbm	kilometer	km
bushel	bu	liquid	liq
Celsius, degree	°C	liter	liter
centigram	cg	meter	m
centiliter	cl	microliter	μl
centimeter	cm	micron	μm
chain	ch	mile	mi
cubic millimeter	mm^3	milligram	mg
decigram	dg	milliliter	ml
deciliter	dl	millimeter	mm
decimeter	dm	ounce	oz
dekagram	dag	ounce, avoirdupois	oz avdp
dekaliter	dal	ounce, liquid	liq oz
dekameter	dam	ounce, troy	oz tr
fathom	fath	peck	peck
foot	ft	pint, liquid	liq pt
gallon	gal	pound	lb
gram	g	quart, liquid	liq qt
hectare	ha	rod	rod
hectogram	hg	second	s
hectoliter	hl	square centimeter	cm^2
hectometer	hm	ton, long	long ton
inch	in	ton, metric	t
International Nautical Mile	INM	ton, short	short ton
Kelvin, degree	°K	yard	yd
kilogram	kg		

12. (km; hm)

Frame 13. Abbreviated Latin prefixes representing decimal multiples of 10 are written in the following manner:

millimeter = ______________________.
centimeter = ______________________.

---

26. (one, left: 17.095194; 1.7095194)

Frame 27. Have you thought about changing kilometers to millimeters?

When converting from one extreme unit to the other, i.e., kilometers to millimeters, figure to the point of the basic unit (the meter), and work the desired number of places beyond that. This would apply figuring either to the right or to the left of the basic unit.

Example:

1.7095194 km = 1,709,519.4 mm.

To change 17.095194 hm to cm, move the decimal point __________ place(s) to the right of the basic unit.

Solve the problems below.

17.095194 hm = ___________________ cm.
170.95194 dam = ___________________ mm.

13. (mm; cm)

Frame 14. The abbreviation used for 10 dekameters is 10 dam.

The abbreviation used for 12 kilometers is 12 ___________.
The abbreviation used for 33 hectometers is 33 ____________.

YOU HAVE JUST COMPLETED LEVEL A.
TURN BACK TO PAGE 105 AND WORK LEVEL B.

---

27. (4; 170.951.94; 1.707,519.4)

Frame 28. When converting from a smaller unit to a larger unit the decimal point is moved to the LEFT. From a larger unit to a smaller unit the decimal point is moved to the RIGHT.

When converting from cm to m the decimal point is moved ____________________ place(s) to the __________________. From hm to m the decimal point is moved ____________ place(s) to the _________________.

GO TO PART II.

28. (2, left; 2, right)

PART II

ENGLISH AND METRIC CONVERSION

The following are problems of conversion between the US customary or English System and the Metric System of length. An example of the problem will be worked for your guidance. Work the remainder of the problems yourself. A copy of "The Metric System Conversion Table" is furnished for your convenience on page 137. Refer to it often. When you have arrived at the correct answer, place it on the blank line provided. (Check your answers on page 139.)

Frame 29. A floor plan of a building is illustrated on page 134. Its dimensions are in meters. Convert these dimensions to feet and inches. Refer to "The Metric System Conversion Table" on page 137.

1 m = 3.2808 feet

3.2808 feet = 3' 3" (Approximately)

A. (Example) 3.2808 x 10 m = 32.81 feet. Hence, 32 + (.81 x 12) (12 inches to a foot) = 9.72 inches.
Round off 9.72 to the nearest inch = 10"
Answer: 10 m = 32' 10"

B. 3.2808 x 3.5 m = 11.483 feet. Hence, 11' + (.483 x 12) (12 inches to a foot) = ________.________ inches.
Round off 5.796 "to the nearest inch = __________________".
Answer: 3.5 m = _____' _____"

Note: When a decimal fraction has a value of .5 or more, round off to the next higher number.

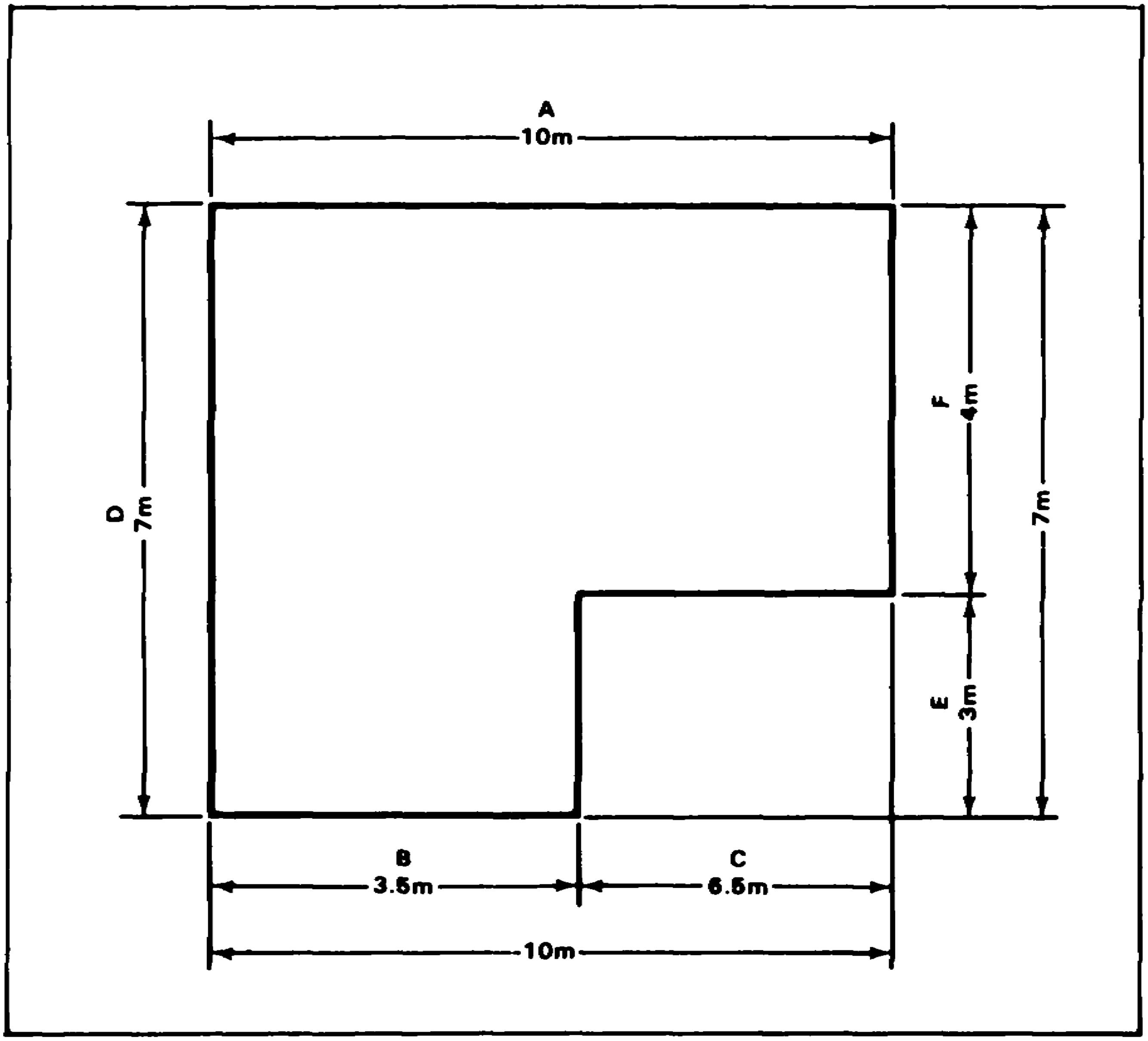
C. 6.5 m = _____' _____"
(Use the same method as shown in Problems A and B to figure the remainder of the problems.)

D. 7 m = _____' _____".

E. 3 m = _____' _____".

F. 4 m = _____' _____".

WORK PROBLEMS IN THIS AREA



WORK PROBLEMS IN THIS AREA

Frame 30. We are constructing a section of road 90 kilometers (km) long; how many miles is this? How many feet?

See the conversion table on page 137.

Examples: 9 (km) x 0.62137 = 5.59 miles
9 (km) x 3280.8 = 29.529 feet

0.62137 x 90 (km) = _________._______ miles.

3280.8 x 90 (km) = _________________ feet.

Frame 31. Reduce 456 inches to centimeters; 435 feet to meters.

See the conversion table on page 137.

Examples: 45 (inches) x 2.54 = 114.30 cm.
43 (feet) x 0.3048 = 13.1064 m.

456 x 2.54 = __________.________ cm.

435 x 0.3048 = __________.________ m.

WORK PROBLEMS IN THIS AREA

THE METRIC SYSTEM CONVERSION TABLE

Length		Multiply By
in to cm	------------Frame 31----------------	2.54*
ft to m	------------Frame 31----------------	0.3048*
yds to m	------------------------------------	0.9144*
miles to km	------------------------------------	1.609344
mm to in	------------------------------------	0.03937
cm to in	------------------------------------	0.3937
dm to in	------------------------------------	3.937
dm to ft	------------------------------------	0.32808
m to in	------------------------------------	39.37
m to ft	------------------------------------	3.2808
m to yds	------------------------------------	1.0936
dam to ft	------------------------------------	32.808
hm to ft	------------------------------------	328.08
km to ft	------------Frame 30----------------	3280.8
km to yds	------------------------------------	1093.6
km to miles	------------Frame 30----------------	0.62137
Weight		
pounds to kg	------------Frame 33-----------------	0.45359237*
kg to pounds	------------Frame 34-----------------	2.204623
Volume		
qts to liters	--------------------------------------	0.946352946*
liters to qts	------------Frame 32 and 34-----------	1.05669
liters to gallons	------------Frame 32 and 34-----------	0.264172

*Exact Figures

Frame 32. Reduce 750 liters to the following units: quarts, gallons.

See the conversion table on page 137.

Examples: 75 (liters) x 1.05669 = 79.252 quarts.
79.252 ÷ 4 (or x 0.264172) = 19.813 or 20 gallons.

750 x 1.05669 = _____._____ quarts.

_____._____ ÷ 4 (or x 0.264172) = _____._____ gallons.

Frame 33. A man weighs 176 pounds. What is his weight in kg?

See the conversion table on page 137.

Example: 17 (lbs) x 0.45359237 = 7.711 kg.

176 x 0.45359237 = _____._____ kg or _______ kg.

Frame 34. A certain mixture of concrete calls for -

42 kilograms (kg) of cement
15 liters (l) of water

How much is each of these in pounds and gallons respectively?
See the conversion table on page 137.

Examples: 4 (kg) x 2.204623 = 8.8 pounds.
7 (l) x 1.05669 = 7.397 quarts or 1.849 gallons.

42 x 2.204623 = _____._____ pounds.

15 x 1.05669 = 15.850 quarts or _____._____ or ______ gallons.

WORK PROBLEMS IN THIS AREA

Answers for Part II

Frame 29

A. 32' 10" (example)
B. 11' 6″
C. 21' 4"
D. 23' 0"
E. 9' 10"
F. 13' 1"

Frame 30

55.92 miles
295.272 feet

Frame 31

1,158.24 cm
132.5880 m

Frame 32

792.518 quarts
198.129 gallons

Frame 33

79.832 or 80 kg

Frame 34

92.594 pounds
3.963 or 4 gallons

LESSON II SELF-TEST

Before going any further, stop and have a brief review. Feel free to refer to the material you have just covered for guidance.

A. The three common units of measure of the metric system are the __________, __________, and the __________.

B. The Greek prefixes deka, hecto, and kilo represent ____________ numbers.

C. The Latin prefixes deci, centi, and milli represent decimal ____________.

D. Supply the whole or decimal fraction numbers where applicable to represent meters:

kilo	=	______________	meters	deci	=	________________	of a meter
hecto	=	______________	meters	centi	=	________________	of a meter
deka	=	______________	meters	milli	=	________________	of a meter

E. List the proper abbreviations of given units of lengths.

kilometer	=	__________	decimeter	=	__________
hectometer	=	__________	centimeter	=	__________
dekameter	=	__________	millimeter	=	__________

F. 1,709.5194 m =

__________ km	__________ dam	__________ cm
__________ hm	__________ dm	__________ mm

LESSON II SELF-TEST ANSWER SHEET

Metric System, Metric Scale, and System

A. meter, gram, liter

B. whole

C. fractions

D. kilo = 1.000 meters

hecto = 100 meters

deka = 10 meters

deci = .1 of a meter

centi = .01 of a meter

milli = .001 of a meter

E. kilometer = km

hectometer = hm

dekameter = dam

decimeter = dm

centimeter = cm

millimeter = mm

F. 1,709.5194 m

1,7095194 km

17.095194 hm

170.95194 dam

17.095.194 dm

170,951.94 cm

1,709,519.4 mm

LESSON III

MEASURING SCALES

OBJECTIVE:	At the end of this lesson you will be able to work with and read the engineer scale, metric scale, and invar scale related to basic mapping techniques.
TASKS:	Related task numbers. 051-257-1203 Construct Map Grids 051-257-1204 Construct Map Projections 051-257-1205 Plot Geodetic Control 051-257-2213 Determine Aerial Photography Scales 051-257-2236 Compute Enlargement/Reduction Factors 051-257-2238 Construct Controlled Photomosaics
CONDITIONS:	You will have this subcourse booklet and you will work on your own.
STANDARDS:	You must correctly answer the questions in the written performance test with 75 percent accuracy.
CREDIT HOURS:	1 1/2
REFERENCES:	None

EXTRACT OF TM 5-240

INSTRUCTIONAL CONTENT

The engineer scale, metric scale, and invar scale are used to make precise measurements. To be a professional cartographer you must be proficient in using these scales to obtain and make precise measurements. The scales that you learn to use in this lesson will enable you to easily perform tasks presented in later subcourses. Before taking the self-test you should work through the following sections and read the extract from TM 5-240 on the invar scale.

1. THE ENGINEER SCALE

LEVEL A

Frame 1. The proper use of drafting scales enables a draftsman to lay out proportional dimensions quickly, easily, and accurately.

Now complete response 1, at the top of the facing page.

LEVEL B

8. (triangular)

Frame 9. The triangular-shaped engineer's scale has the greatest advantage because it has six ratio selections on the one instrument.

Complete response 9, level B.

LEVEL C

16. (decimally)

Frame 17. The engineer's scale is used primarily for civil engineering drawings, such as plot or site, roads, and airfield plans.

Complete response 17, level C.

LEVEL A

Response 1. A draftsman is able to lay out proportional dimensions quickly, easily, and ______________________ with the proper use of drafting scales.

Go to frame 2, level A, next page.

LEVEL B

Response 9. The greatest advantage of the triangular-shaped engineer's scale is that it has __________________________ ratio selections on the instrument.

Go to frame 10, level B.

LEVEL C

Response 17. The scale that would be used for road construction plans is the _____________________ ______________________.

Go to frame 18, level C.

LEVEL A

1. (accurately)

<u>Frame 2</u>. Usually full size drawings are not practical; therefore, the draftsman must make the drawings either to a reduced or enlarged scale.

Complete response 2, level A.

LEVEL B

9. (six)

<u>Frame 10</u>. The scale is usually made of boxwood with a plastic coating. Care should be taken to protect this plastic coating at all times.

Complete response 10, level B.

LEVEL C

17. (engineer's scale)

<u>Frame 18</u>. The standard engineer scale is broken down into units and tenths of a unit.

Complete response 18, level C.

LEVEL A

Response 2. Drawings are usually made either to __________________ or __________________ scale.

Go to frame 3, level A.

LEVEL B

Response 10. The material used to make this scale is boxwood with a ____________________ coating.

Go to frame 11, level B.

LEVEL C

Response 18. When reading a scale of 1" - 10', the subdivisions of that inch equal _____________________ foot.

Go to frame 19, level C.

2. (reduced, enlarged)

<u>Frame 3</u>. A knowledge of the available scales is necessary to insure that the proper scale is used for a particular job.

Complete response 3.

---

10. (plastic)

<u>Frame 11</u>. Never attempt to transfer a dimension from this scale by placing the dividers directly on the scale. It will scratch or disfigure the graduations on the scale.

Complete response 11.

---

18. (one)

<u>Frame 19</u>. The units of the standard engineer's scale can represent any unit of measure. For example, a unit can represent one inch, one foot, one hundred feet, or one thousand feet.

Complete response 19.

LEVEL A

Response 3. The draftsman must be able to select the proper ________________ for a particular job.

LEVEL B

Response 11. Dividers are not placed directly on the _________________.

LEVEL C

Response 19. A ___________________ on the engineer's scale can represent any unit of measure.

LEVEL A

3. (scale)

Frame 4. The four most common drafting scales are the engineer's scale, the architect's scale, the metric scale, and the graphic scale.

LEVEL B

11. (scale)

Frame 12. When cleaning the engineer's scale, use only a slightly dampened towel or cloth and rub softly. Too much water will result in the wood warping or in the plastic coating becoming loose.

LEVEL C

19. (unit)

Frame 20. When making a measurement from the scale of 1" - 20', you should select the scale that has 20 subdivisions to the inch.

LEVEL A

Response 4. The ______________ scale, architect's scale, ______________ scale, and graphic scale are the four most common drafting scales.

LEVEL B

Response 12. The best way to clean the scale is with a _______________ dampened towel or cloth.

LEVEL C

Response 20. The scale that has two full units to the inch has ___________ subdivisions to the inch.

LEVEL A

4. (engineer, metric)

<u>Frame 5</u>. When referring to a drawing made to scale, the "scale" is used to indicate the ratio of the size of the view as drawn to the true dimensions of the object.

LEVEL B

12. (slightly)

<u>Frame 13</u>. Of the six scale selections on the triangular-shaped engineer's scale, three are located on the left end, and three are located on the right end.

LEVEL C

20. (20)

Frame 21. The correct method to make a measurement using the engineer's scale is to place the scale on the drawing, align the scale in the direction of measurement, and mark with a sharp pencil at the desired graduation mark.

LEVEL A

Response 5. The "scale" is used to indicate the _______________ of the size of the view as drawn to the true dimensions of the object.

LEVEL B

Response 13. ___________________ scale selections are located on the left end of the triangular-shaped engineer's scale and _____________________ selections are located on the right end.

LEVEL C

Response 21. After placing the scale on the drawing and aligning in the direction to be measured, mark the point at the desired _________________ mark.

LEVEL A

5. (ratio)

Frame 6. Enlarged scales may be used when the actual size of the object is so small that full-size representation would not clearly represent the features of the object.

LEVEL B

13. (three, three)

Frame 14. To read the triangular engineer's scale, position it so that the selected scale is read from left to right.

LEVEL C

21. (graduation)

Frame 22. Successive measurements on the same line should be made without shifting the scale. This helps to avoid chances for error.

LEVEL A

Response 6. An _____________ view of an object shows the object at a larger scale than the true dimensions indicate.

LEVEL B

Response 14. When reading the triangular engineer's scale, the selected scale is read from __________________ to ___________________.

LEVEL C

Response 22. To help limit the chances for _______________, as many successive measurements as possible should be made without moving the scale.

LEVEL A

6. (enlarged)

<u>Frame 7</u>. An engineer's scale is divided decimally into ratios of 10, 20, 30, 40, 50, and 60 parts of an inch.

LEVEL B

14. (left, right)

<u>Frame 15</u>. The scale is divided uniformly throughout its length and is classified as fully divided.

LEVEL C

22. (errors)

Frames 23 through 34 are in Lesson II, pages 121 through 139. If you have completed them, turn now to page 163.

LEVEL A

Response 7. The engineer's scale has six ratio selections; they are __________, __________, __________, __________, __________, and __________ parts to an inch.

LEVEL B

Response 15. A fully divided scale is divided throughout its _________________.

7. (10, 20, 30, 40, 50, 60)

Frame 8. The scale itself can be either triangular-shaped or flat with square or beveled edges.

---

15. (length)

Frame 16. Because the scales are divided decimally, the 60 scale, for example, can be used so that one inch equals 6, 60, or 600 feet.

LEVEL A

Response 8. The shape of the scale can be either __________ shaped or flat.

Go to frame 9, level B, page 146.

LEVEL B

Response 16. The engineer's scale is divided __________________.

Go to frame 17, level C, page 147.

You have just completed Part 1 of this lesson. There are two more sections to go. This section involves the metric scale and how to use it. Before you turn this page and dig in, take out your metric scale because you will be using it.

Ready?

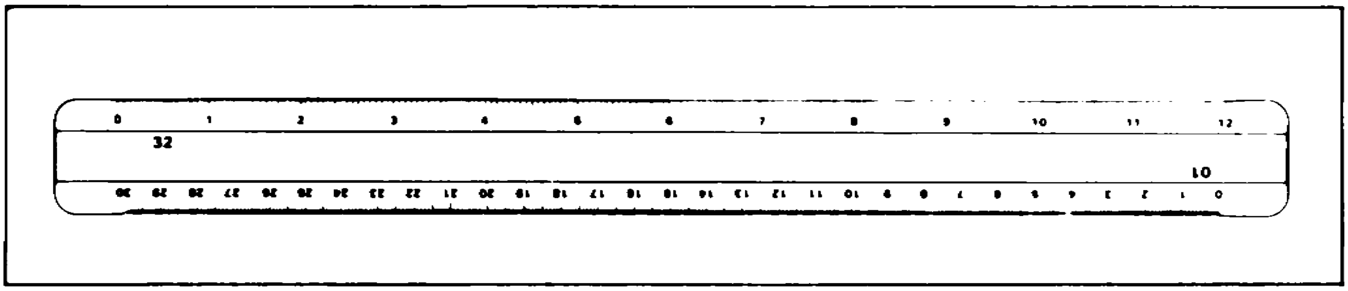
Then let's go!

START WITH PART 2, FRAME 35, LEVEL A.

2. METRIC SCALE

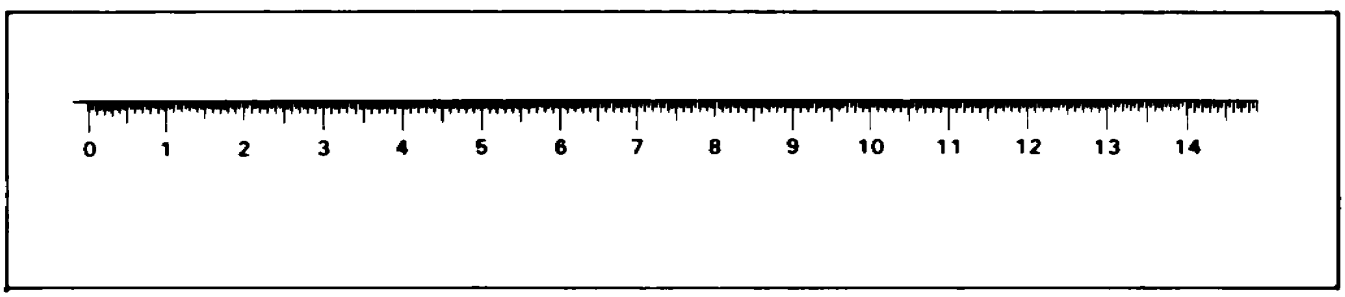
LEVEL A

Frame 35. A metric scale is a device used for making measurements in millimeters, centimeters, and decimeters. Therefore, a device used for making metric measurements is called a _______________ scale.



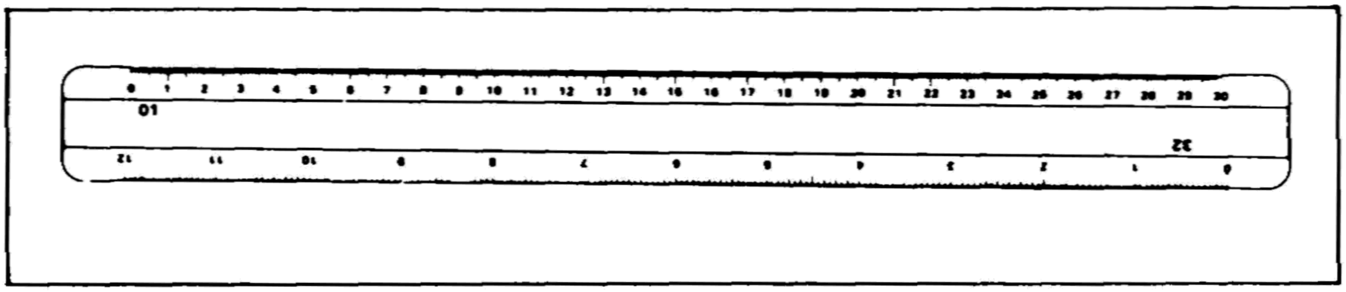
LEVEL B

Frame 48. The third longest set of lines on the scale represents _______________ of a centimeter.



35. (metric)

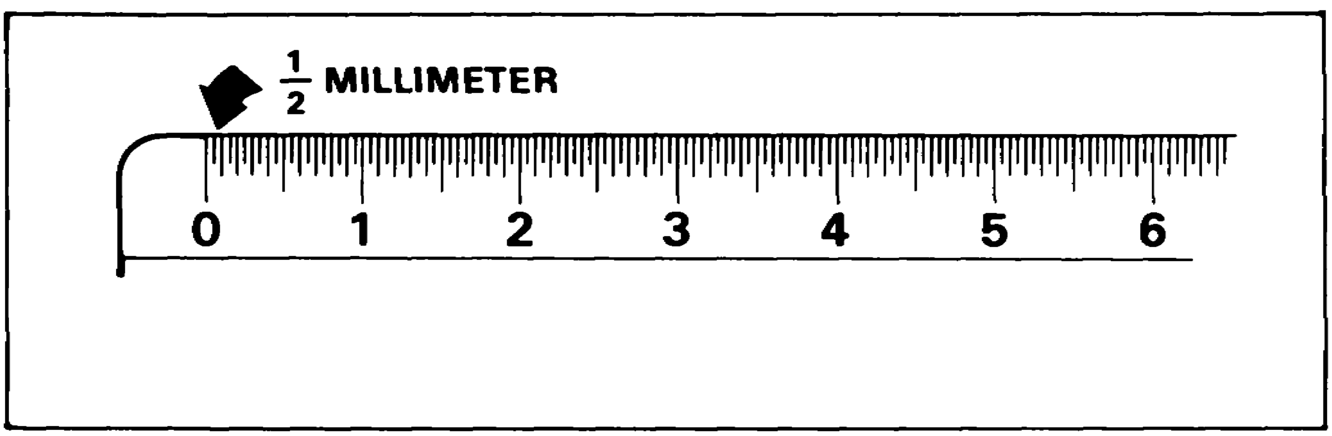
Frame 36. Precise measuring is done with a _______________ _______________.



48. (1/10)

Frame 49. The shortest set of lines on the scale is halfway between 0 and 1 mm, 1 mm and 2 mm, 2 mm and 3 mm, 3 mm and 4 mm, etc. This divides the centimeter into 20 equal parts. Each part is called 1/2 mm.

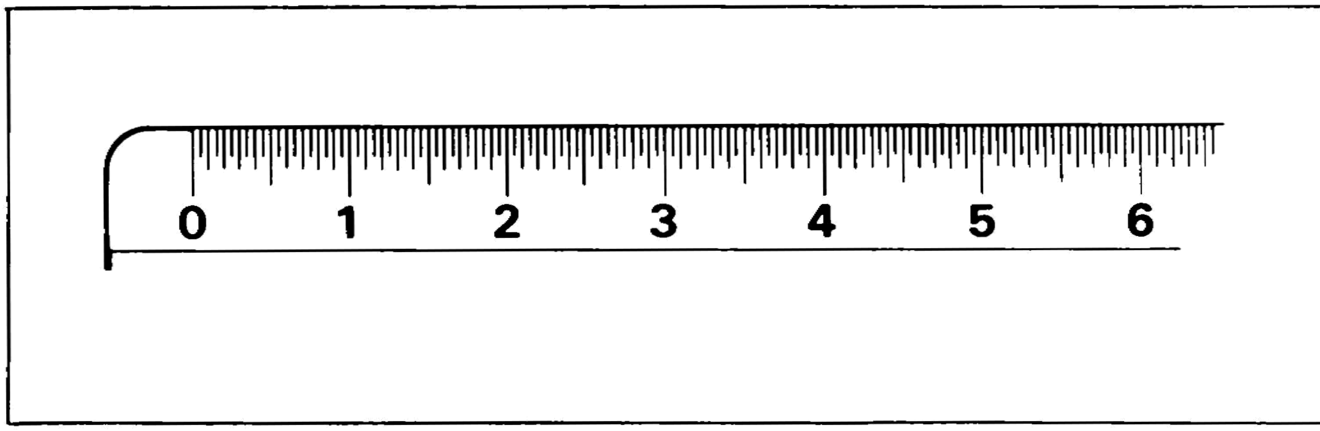
The shortest set of lines divides the centimeter into 20 equal parts. Therefore, this scale is known as a 1/2 millimeter scale. (See illustration below.)



36. (metric scale)

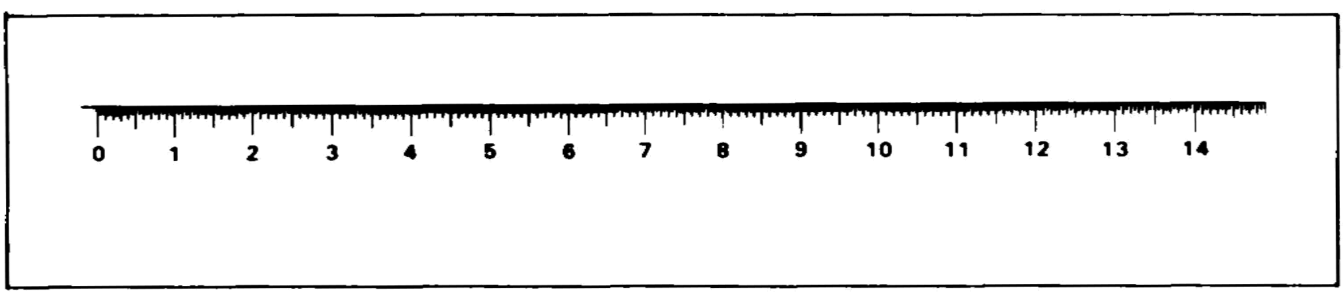
Frame 37. The metric scale is divided into equal units. On this scale each unit is given a number and these units are called centimeters (cm).

Therefore, the units of measure on this scale are called ________________________.



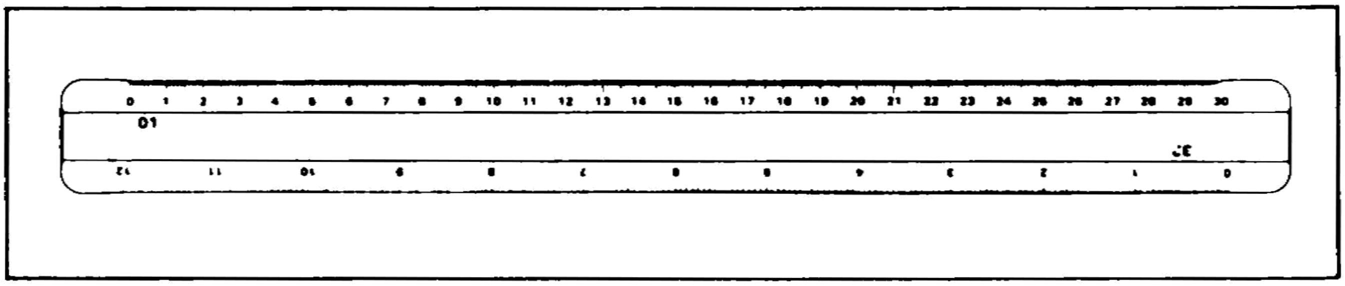
Frame 50. If the third longest set of lines divides the centimeter into 10 equal parts, then each of the 10 parts is equal to ONE millimeter, 0.001 meter of $\frac{1}{1000}$ meter.

One millimeter (mm) = $\frac{1}{1000}$ m or __________ meter.



37. (centimeters)

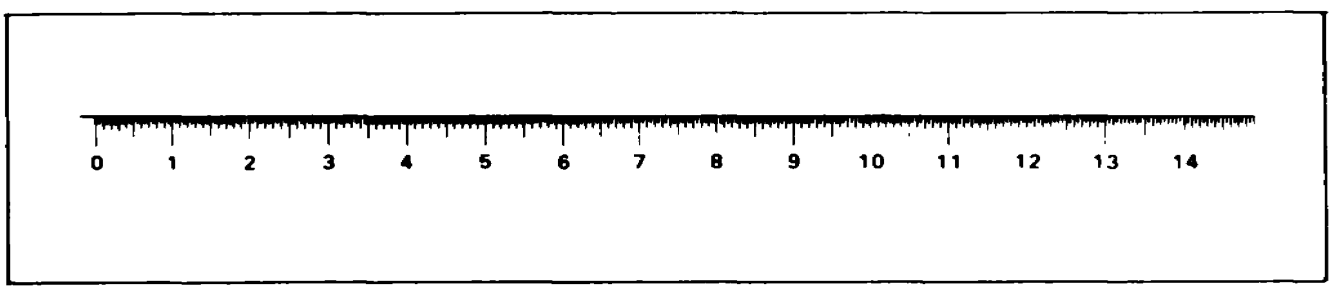
Frame 38. A device used for making measurements in centimeters and divided by decimal fractions is called a ______________________________.



50. (0.001)

Frame 51. The second longest set of lines on the scale represents 1/2 of a centimeter or 5 millimeters which is equal to 1/200 of a meter.

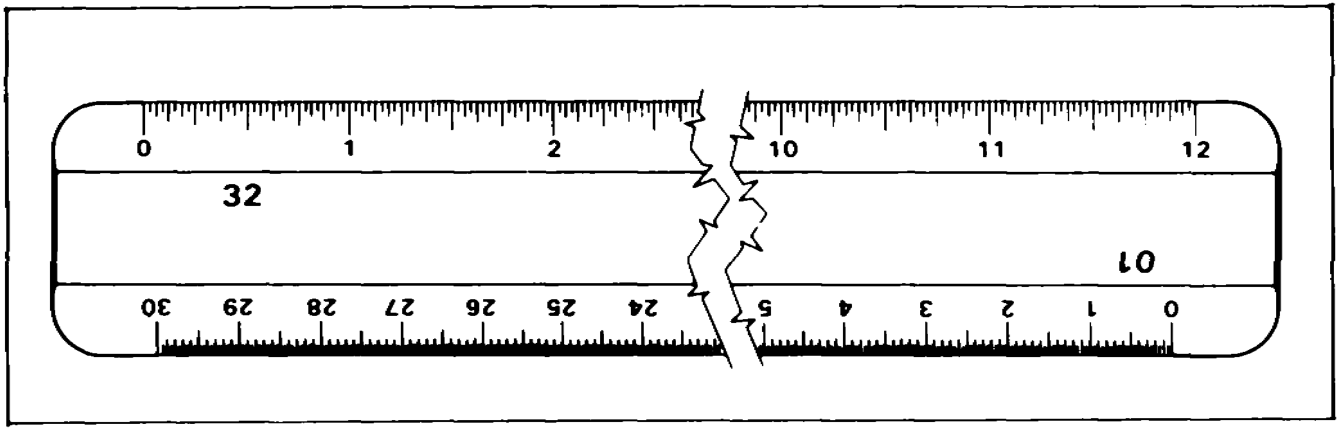
Five millimeters (mm) = .005 m or __________ of a meter.



38. (metric scale)

<u>Frame 39</u>. A <u>decimal fraction</u> is any part of an object, unit, or number whose denominator is a multiple of 10.

Therefore, it can be said that any part of an object, unit, or number can be expressed as a __________ fraction.



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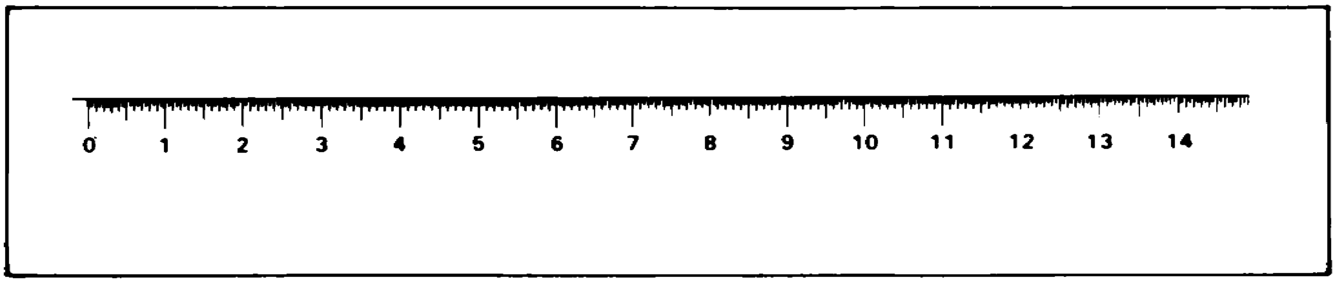
51. (1/200)

<u>Frame 52</u>. There are 10 marks (including the whole centimeter line) between each centimeter on the scale dividing the cm into 10 equal parts or a fraction of 1/10 of a decimeter.

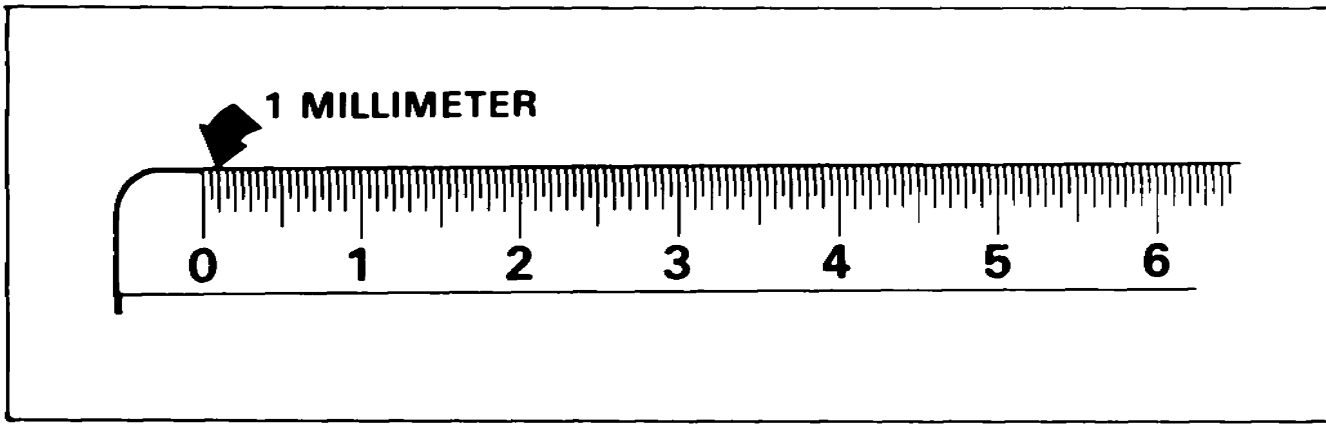
Each centimeter on the scale is divided into __________ equal parts.



39. (decimal)

<u>Frame 40</u>. The metric scale is divided into centimeters, then subdivided into fractions (1/10 of a centimeter = one millimeter).

Measurements of less than a centimeter on this scale are termed _____________.



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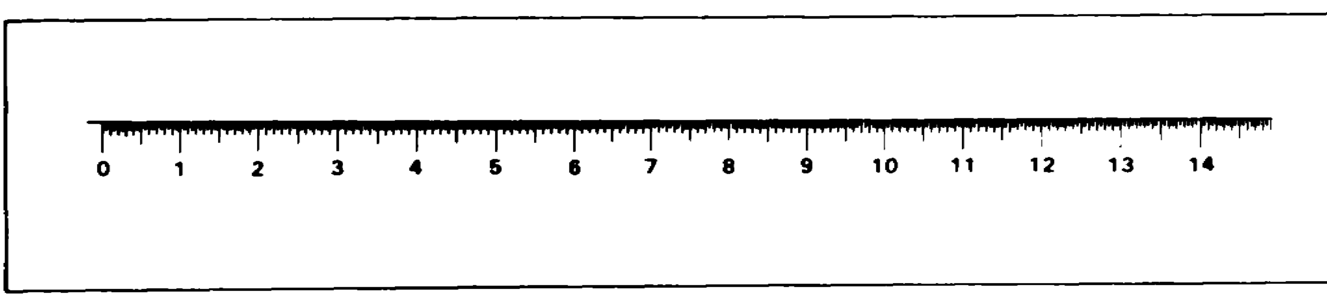
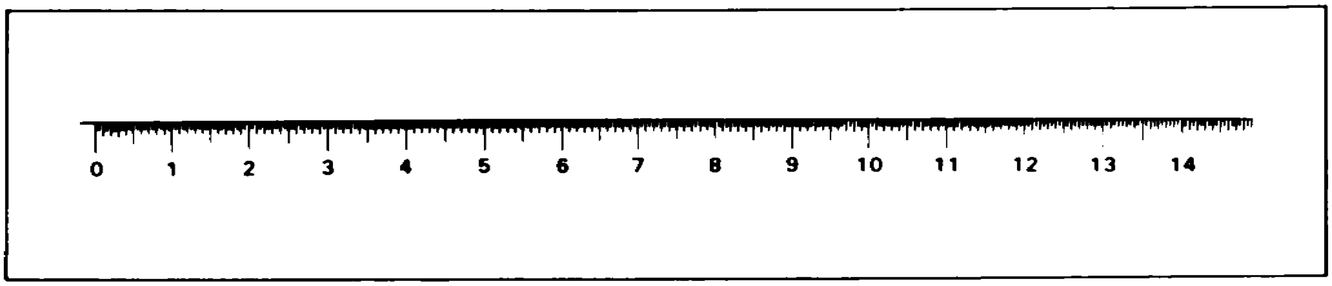
52. (10)

<u>Frame 53</u>. If there are 10 equal parts to the centimeter, then each of the 10 parts is equal to 0.1 or __________ of a centimeter.



40. (millimeters)

Frame 41. In order to make measurements of less than a centimeter, e.g., 1/10 or 1/20, the scale is divided into decimal of a centimeter.



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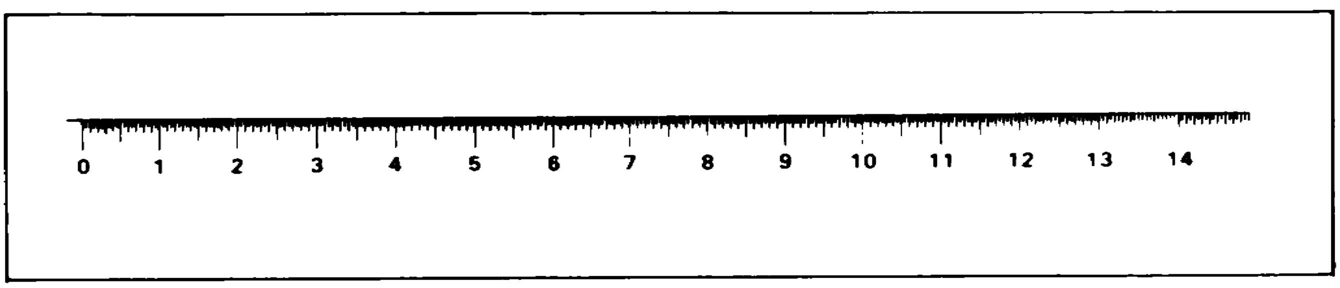
53. (1/10)

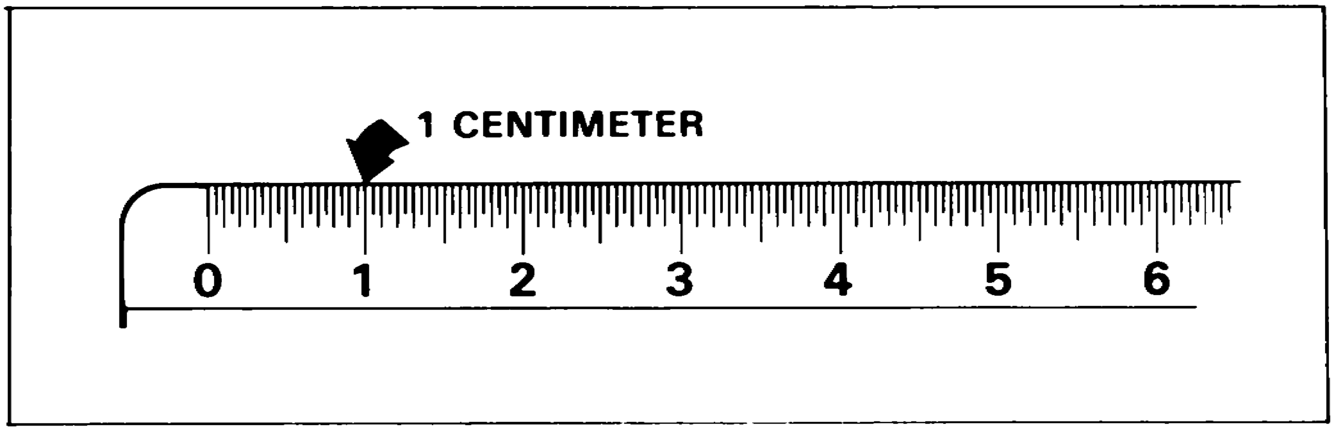
Frame 54. A decimal fraction of 1/20 of a centimeter is represented by the shortest line on the scale and is the minimum measurement that can be read.

The shortest line on the ruler represents __________ of a centimeter.



41. (fractions)

Frame 42. The vertical marks on the scale are of different lengths. Each mark represents a decimal fraction of a centimeter. For example, the longest mark represents a centimeter (cm) and is numbered.



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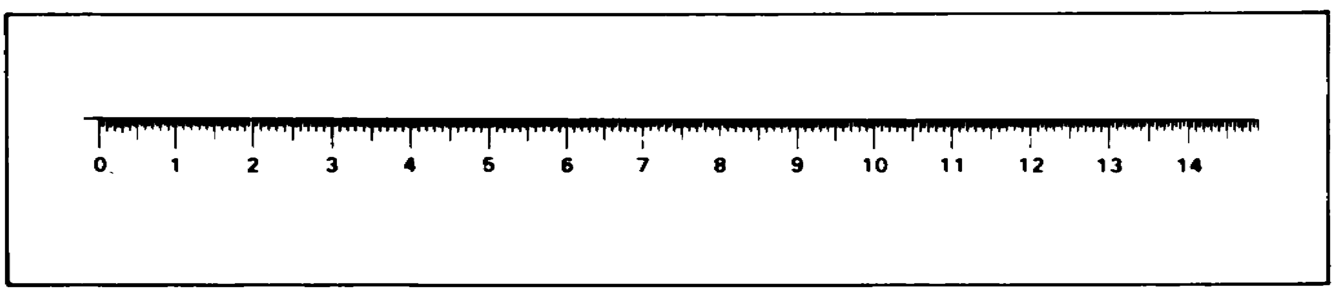
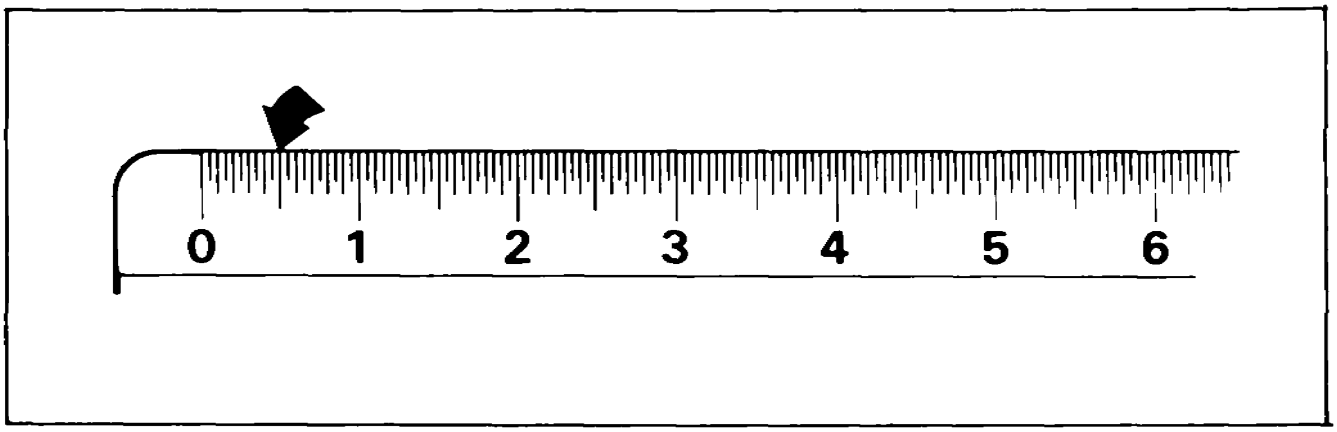
54. (1/20)

Frame 55. The minimum measurement that can be read on this scale is __________ of a millimeter.



Frame 43. Looking at the scale, you will see that the second longest set of lines is exactly halfway between the numbered units, e.g., 0 and 1. This line divides the centimeter into two equal parts or 5 millimeters.

The second longest line divides the centimeter into _________ equal parts.



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55. (1/2)

Frame 56. You should know that -

One millimeter (mm) = 1/1000 meter.

Ten millimeters (mm) = one centimeter (cm).

Ten centimeters (cm) = one decimeter (dm).

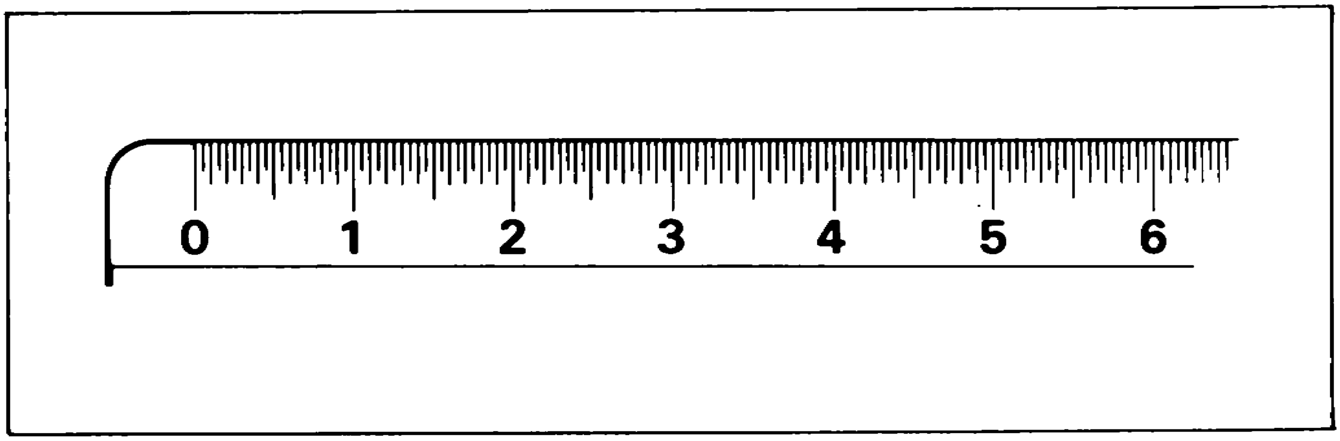
Ten decimeters (dm) = one meter (m).

The basic unit of length measurement using the metric system is the meter.

The ______________ is adopted as the basic unit of length when using the metric system.

43. (two)

Frame 44. If the second longest set of lines divides the centimeter into two equal parts, then each part is equal to __________ millimeters.



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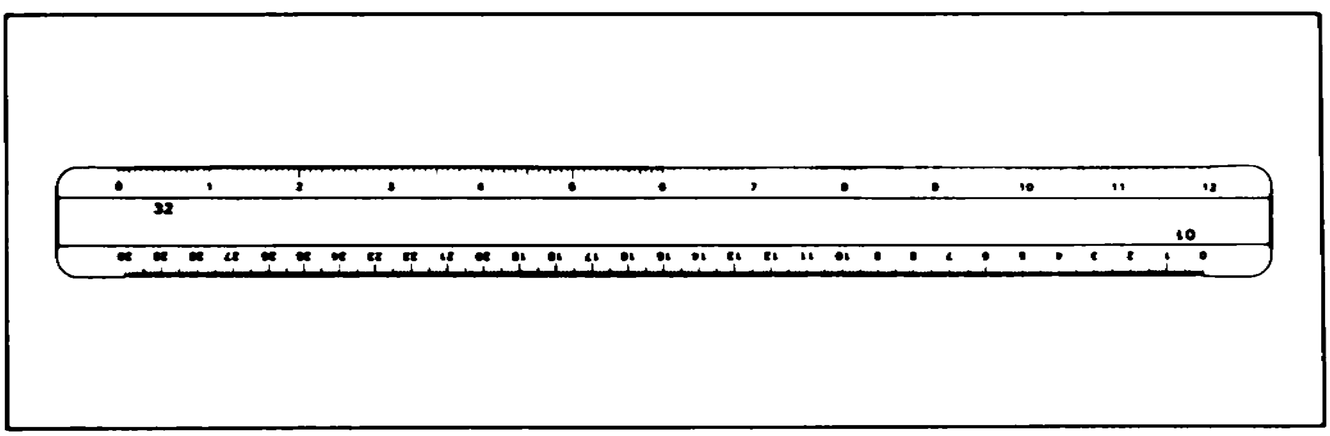
56. (meter)

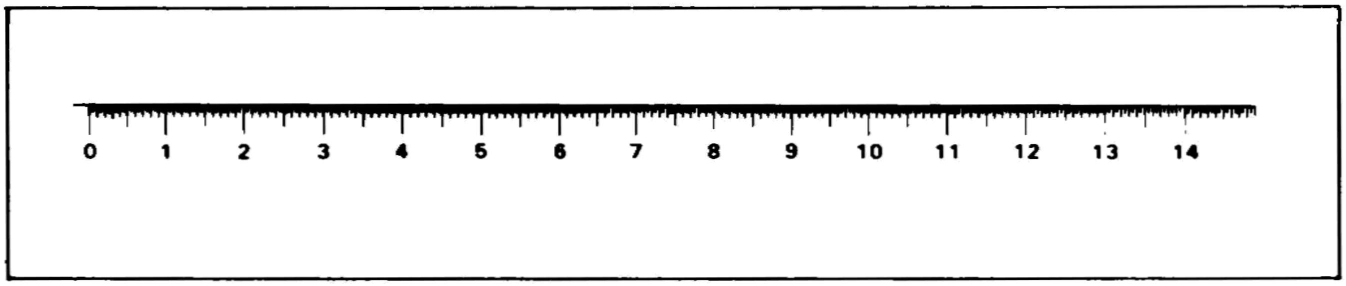
Frame 57. This metric scale is 30 centimeters long. There are 10 centimeters in one decimeter. Therefore, you can measure three decimeters with this scale.

Using this scale, you can measure a maximum of 30 centimeters or __________ decimeters.



44. (five)

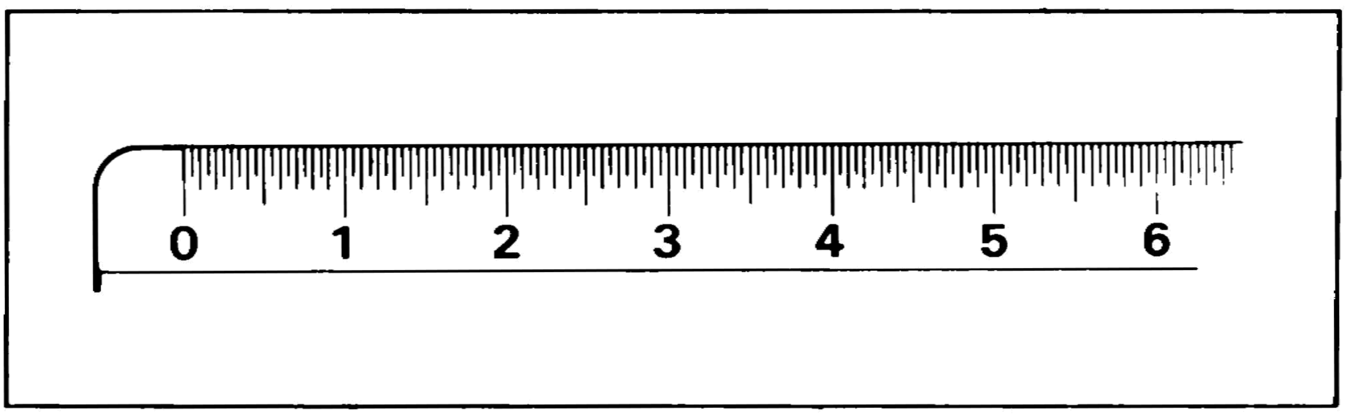
Frame 45. The second longest set of lines on the scale represents __________ __________ centimeter.



57. (three)

Frame 58. Given: 10 millimeters (mm) = 1 centimeter (cm)

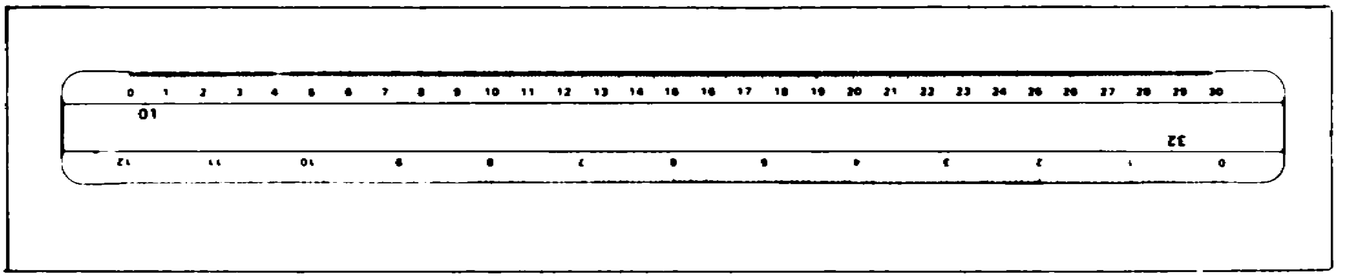
If 20 millimeters = 2 centimeters, then 30 millimeters = __________ centimeters (cm), and 40 millimeters = __________ centimeters.



45. (one half)

<u>Frame 46</u>. Note that the third longest set of lines on the scale is between 0 and .5 cm and between .5 cm and 1 cm. This divides the centimeter into <u>ten</u> equal parts.

The third longest set of lines divides the centimeters into __________ equal parts.



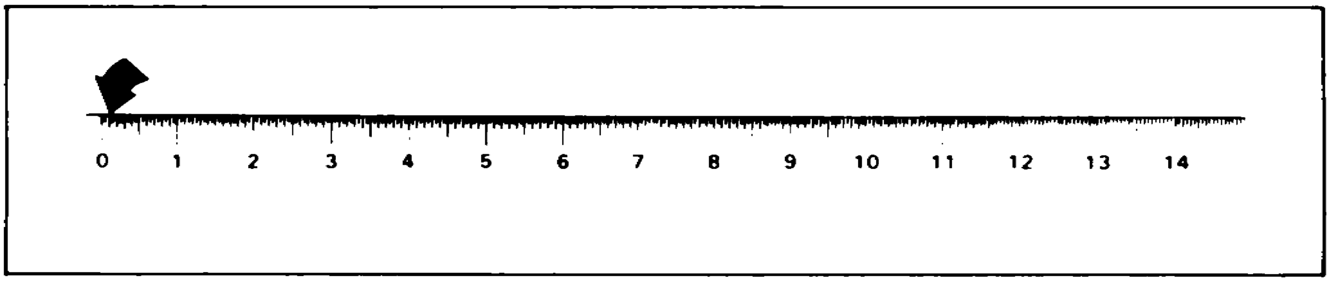
58. (three, four)

Frame 59. At a scale of 1:100, a measurement of 10 cm on the map would equal 10 meters on the ground. There are 100 centimeters (cm) in 1 meter (m).

Your scale is 1:100; therefore, one cm on the map would equal __________ meter on the ground.

46. (10)

Frame 47. If the third longest set of lines divides the centimeter into 10 equal parts, then each of the 10 parts is equal to __________ millimeter.



59. (one)

Frame 60. At a scale of 1:1000, a measurement of 10 cm on the map would equal 100 meters on the ground; one centimeter (cm) equals 1/100 of a meter.

Ten meters on the ground would equal __________ cm on the map.

47. (one)

YOU HAVE JUST COMPLETED LEVEL A.
TURN BACK TO PAGE 165 AND WORK LEVEL B.

---

60. (one)

THINKING IN METERS

SOME RULES OF THUMB

MILLIMETERS (mm) are usually used when dimensioning thicknesses, such as sheets of metal, glass, etc.

8 mm = 5/16"
10 mm = 3/8"
16 mm = 5/8"
35 mm = 1 and 3/8"

1/2" = 12.7 mm
1/4" = 6.4 mm
1/8" = 3.2 mm
24 gage sheet steel = .635 mm (.025 inches)

CENTIMETERS (cm)

PIPE SIZES:
3/8" = 1 cm
3/4" = 2 cm
1" dia. pipe = 2.5 cm (25 mm)

BOOK SIZES:
equipment of this size and sheets of paper:
8" x 10" = 20 cm x 25 cm
one foot = 30 cm+

DESK SIZES:
and equipment of this size
2' x 3' = 60 cm x 90 cm
20" high = 50 cm high+

WINDOW SIZE:
2' x 5' = 60 cm x 150 cm+

METERS (m)

DOOR SIZE:
6' 8" x 2' 8" = 2.00 m x .80 m

AVERAGE MAN'S HEIGHT:
5' 8" = 1.73 m

BUILDINGS:
20' x 40' = 6 m x 12 m
34' x 67' = 10 m x 20 m

(meter continues)

ROAD SIZES:
20' wide = 6 m
30' wide = 9 m
40' wide = 12 m

KILOMETERS (km)

DISTANCES AND SPEEDS:
10 km = 6 miles
40 km = 25 miles
50 km = 31 miles
80 km = 50 miles
100 km = 62 miles

1 inch = 2.5 cm or 25 mm+
1 foot = 30 cm+
1 yard = 1 m+
1 mile = 1.6 km+
10 miles = 16 km

Note: + = some figures above are only approximate to make it easier to remember.

3. INVAR SCALE

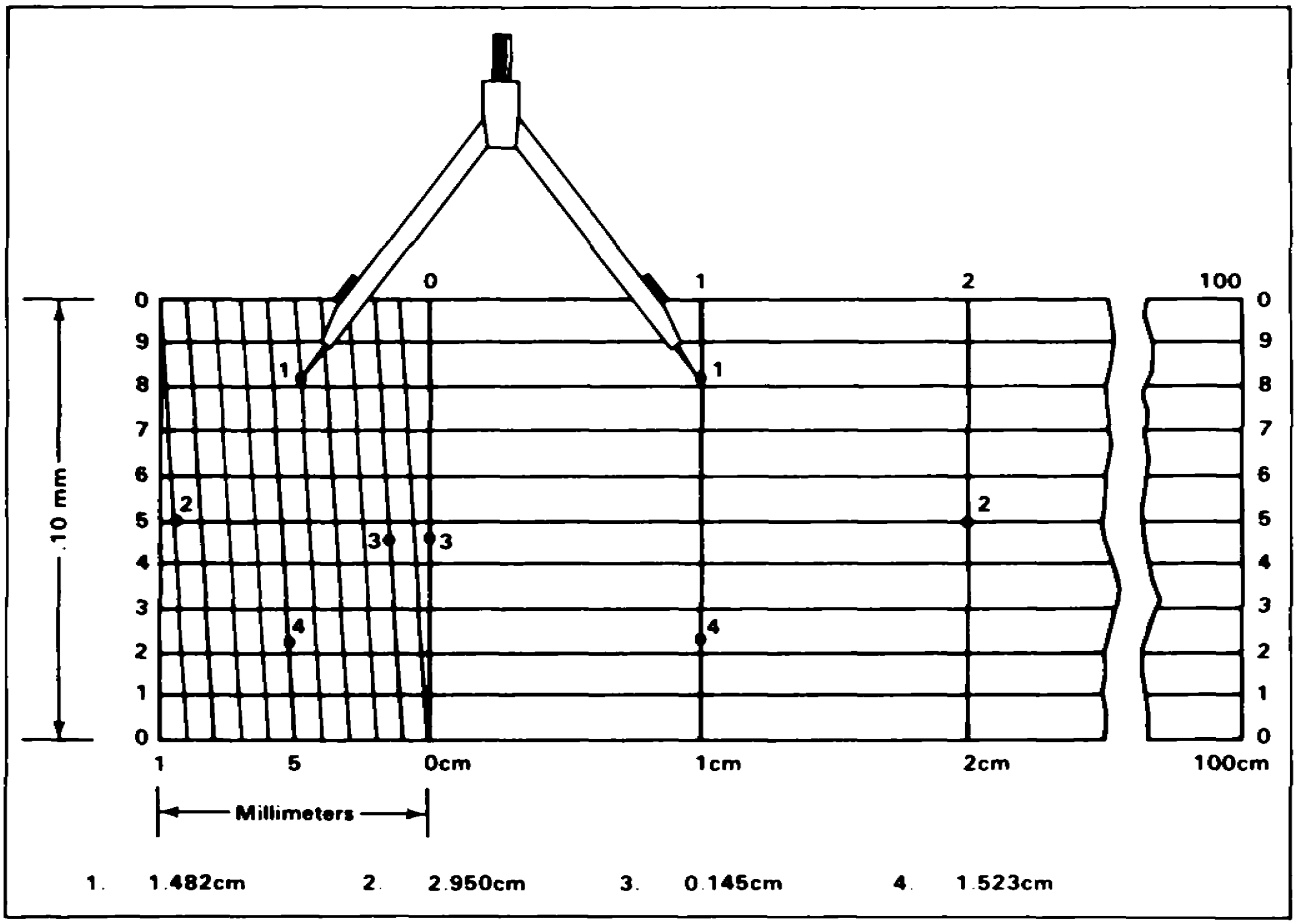
This text on the invar scale is broken down into small steps. It can also be used as a quick reference guide. The invar scale is one of the most important scales you will use as a cartographer.

a. The invar scale is made from a special alloy of nickel and steel which has a low coefficient of expansion; that is, changes in length are insignificant over a wide range of temperature.

b. The scale is kept in a special box for protection. One side of the invar scale is calibrated in the metric system and the other side in the English.

c. The most common sizes are 1 meter and 1 1/2 meters in length, with corresponding English dimensions. On the left end of the bar, one unit--an inch on the English side and a centimeter on the metric side--is graduated in tenths by parallel diagonal lines extending from bottom to top.

d. This unit is further divided into hundredths by parallel horizontal lines extending throughout the length of the bar. The thousandths are estimated along the diagonal between the parallel hundredths lines.

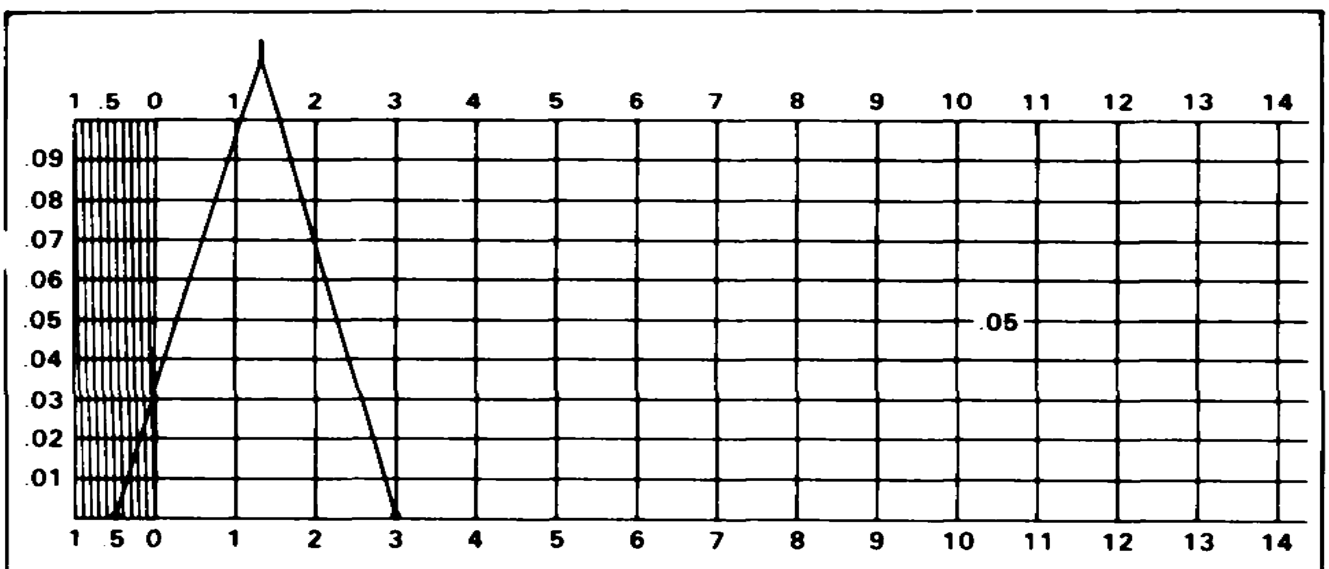


e. The measurements must be made parallel to the horizontal lines at all times. For example, if one end of the compass is on the fourth line from the bottom, the other end must also be on the fourth line.

f. The invar scale should never be taken from its protective box. To use the reverse side, close the box, turn it over, and reopen it. Use care when adjusting the points on the beam compass to a desired measurement to avoid scratching the surface of the scale. Preliminary adjustment should be made on the side of the box.

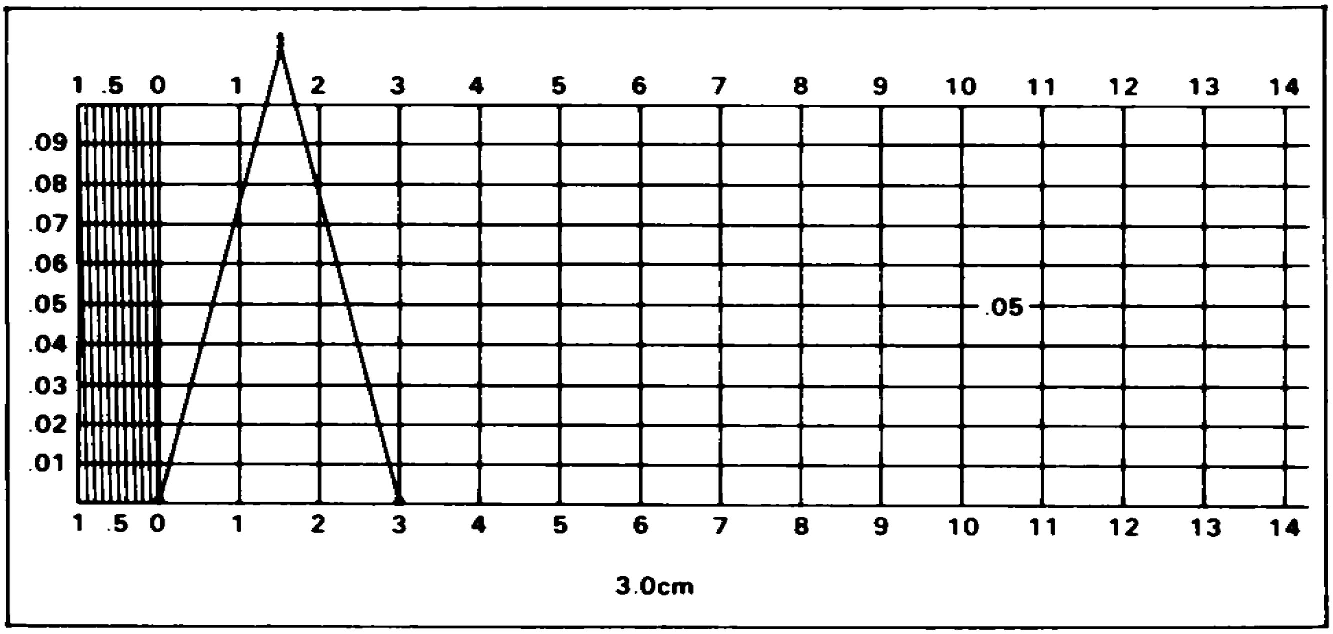
g. Taking measurements from the invar scale involves a simple mechanical technique. The following four steps describe the correct method of setting a measurement accurate to within .001", using a pair of dividers or bar beam compass.

First, place one point of the dividers at the desired whole cm value to the right of the zero line. Insure that the point of the dividers is touching the vertical line representing the number and the bottom line (base line) of the invar scale. Then adjust the dividers until the second point also touches the intersection of the zero vertical line and invar scale base line.

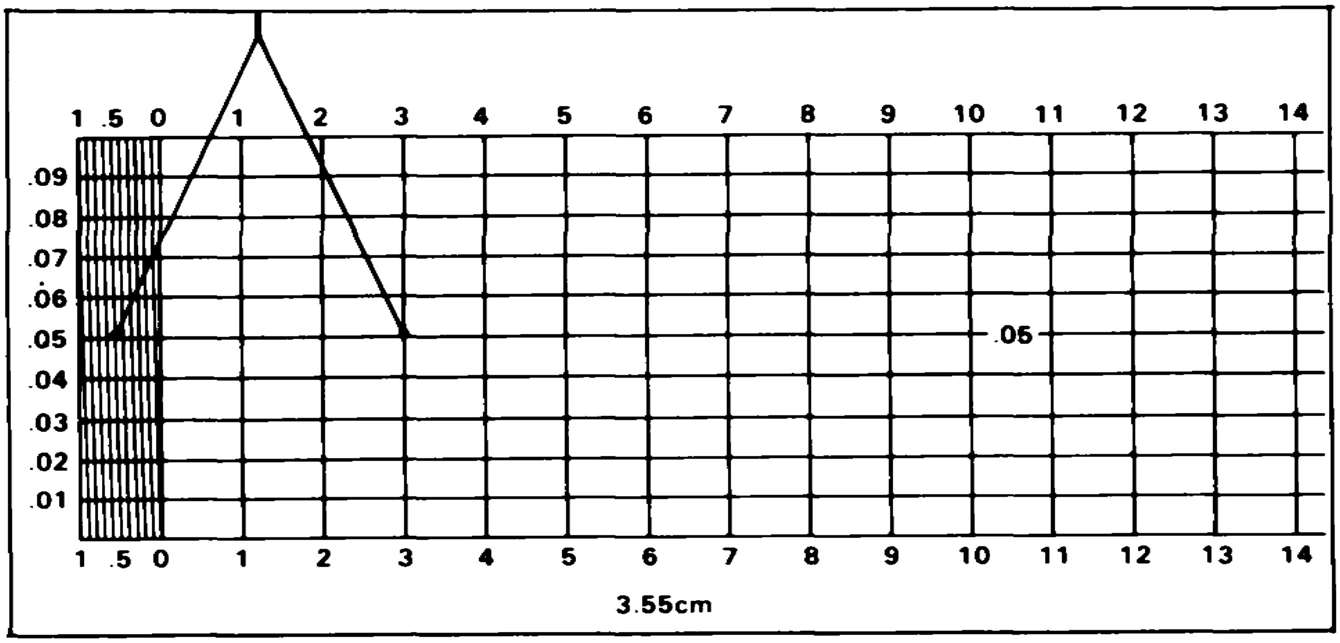


3.5cm

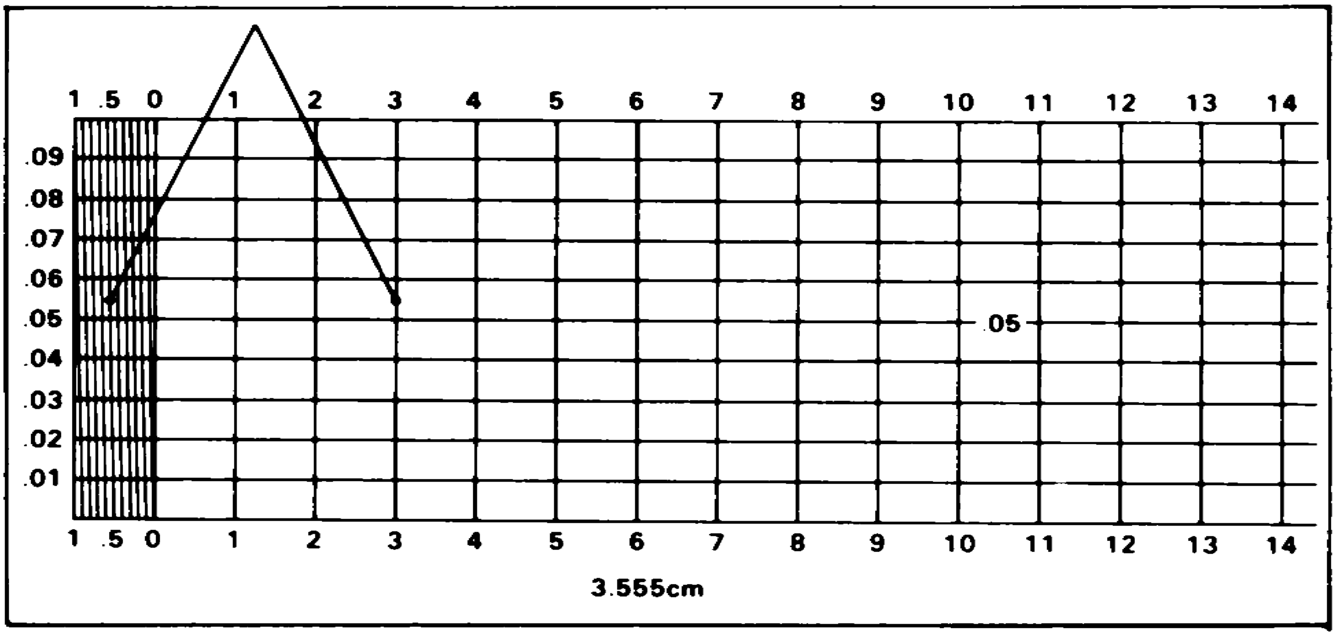
Second, to measure tenths simply adjust the dividers until the second point touches the desired tenths line along the base line.



Third, to accurately measure hundredths, the divider points must be moved vertically on the scale along the line representing the whole number until the desired hundredth value is reached. Then again adjust the dividers until the second point touches the intersection of the vertical tenths line and desired hundredths line.



Finally, to accurately measure thousandths, the procedure is basically the same as the hundredths measurement. Estimate the thousandths between the hundredth line that the dividers are on now and the next higher hundredth line. Place the right divider point at this estimated position, making sure the point remains along the whole number line. Then, keeping the dividers parallel to the base line, adjust the dividers outwards until the second point again touches the vertical tenths line.



LESSON III SELF-TEST

ENGINEER SCALE

The following self-test is designed to help you see how much of the information you have learned from this lesson. Solve each problem listed.

1. A reduced size drawing is made because the object is too _______________ to draw actual size.

2. By having a full knowledge of all available scales, the draftsman can then select the _______________ scale for a particular job.

3. The four most common types of scales are _______________ scale, _______________ scale, _______________ scale, and _______________.

4. The engineer's scale has _______________ ratio selections.

5. The divisions of an engineer's scale are _____, _____, _____, _____, _____, and _____ parts to an inch.

6. The engineer's scale is usually made of boxwood with a _______________ coating.

7. The engineer's scale should be cleaned with a __________ __________ cloth or towel.

8. The scale is positioned so that it can be read from _______________ to _______________.

9. The engineer's scale is used primarily for _______________ engineering drawings.

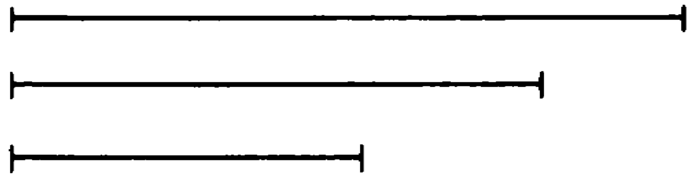
10. The units on the standard engineer's scale can represent any unit of _______________.

11. To help avoid errors, _______________ measurements on the same line should be made without shifting the scale.

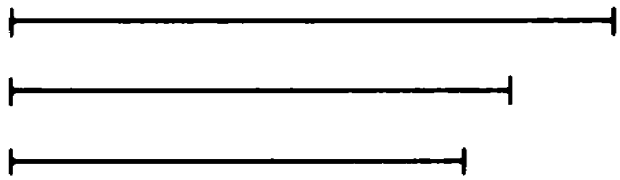
ENGINEER SCALE
SELF-TEST (cont)

SCALE: **LENGTH:**

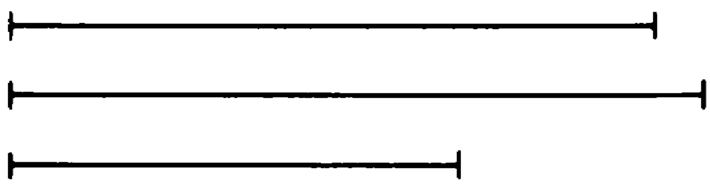
12. 1 in = 1 ft
    1 in = 10 ft
    1 in = 100 ft



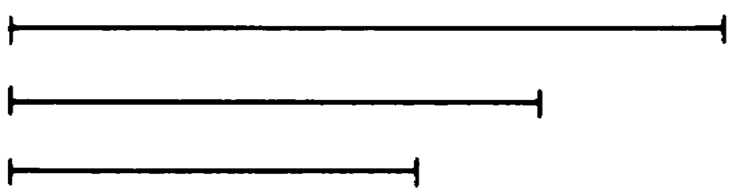
13. 1 in = 2 ft
    1 in = 20 ft
    1 in = 200 ft



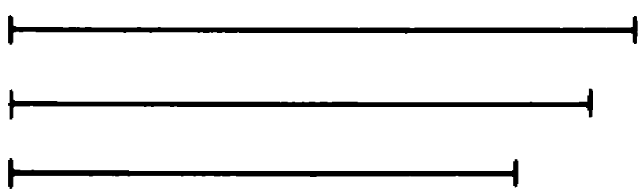
14. 1 in = 3 ft
    1 in = 30 ft
    1 in = 300 ft



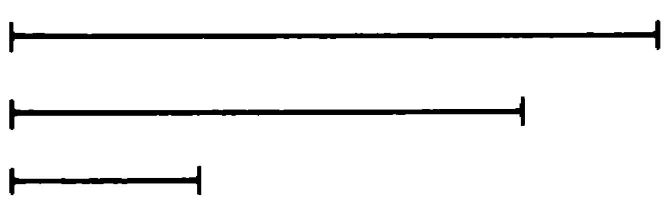
15. 1 in = 4 ft
    1 in = 40 ft
    1 in = 400 ft



16 1 in = 5 ft
   1 in = 50 ft
   1 in = 500 ft



17. 1 in = 6 ft
    1 in = 60 ft
    1 in = 600 ft



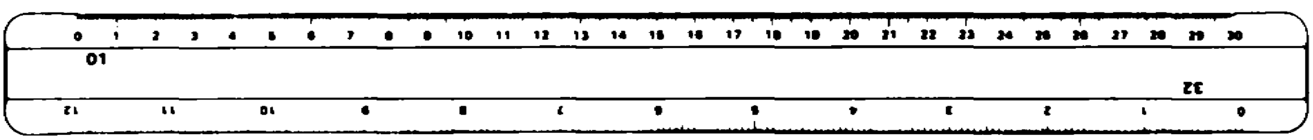
METRIC SCALE

SELF-TEST

The following questions are provided to give you practice in using the information you learned from this text. You should be able to answer ALL questions correctly: but if you miss any, reread the frame in which the answer to the question is found.

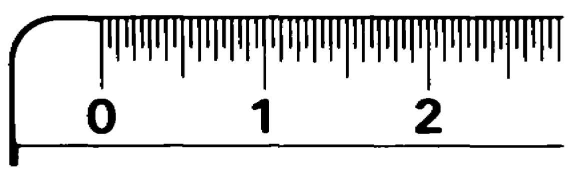
For your convenience, "Thinking in Meters," which appears on page 191, is repeated on page 202. The information may be useful in answering questions in this section.

1. A device used for making measurements in millimeters, centimeters and decimeters is called a _______________ _______________.

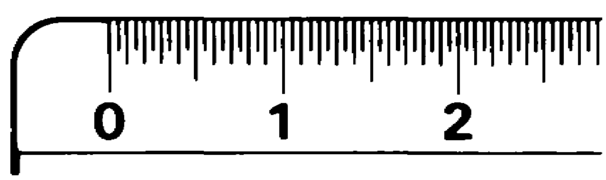


2. The numbered and longest line on this scale represents _______________.

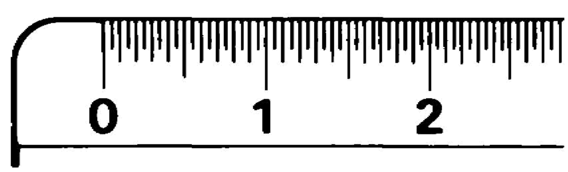
3. In order to measure less than a centimeter, this scale is divided into decimal _______________ or millimeters.



4. The second longest line divides the centimeter into _______________ equal parts.

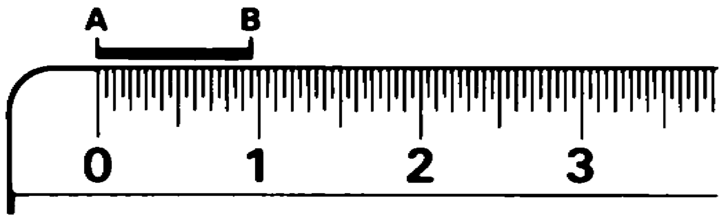


5. The third longest line divides the centimeter into _______________ equal parts or (one) millimeter.

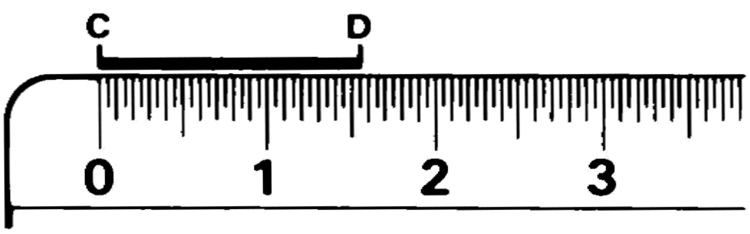


6. The shortest line on this scale represents _______________ millimeter.

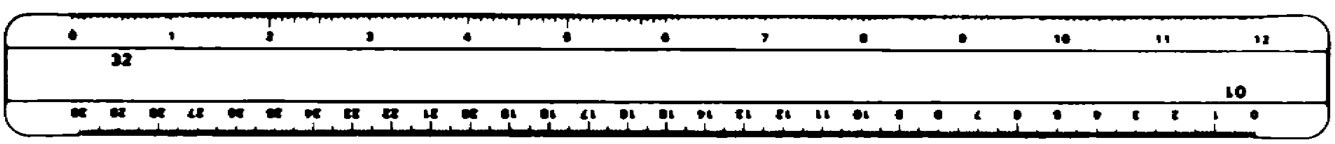
7. What is the measurement of line A-B? _______________



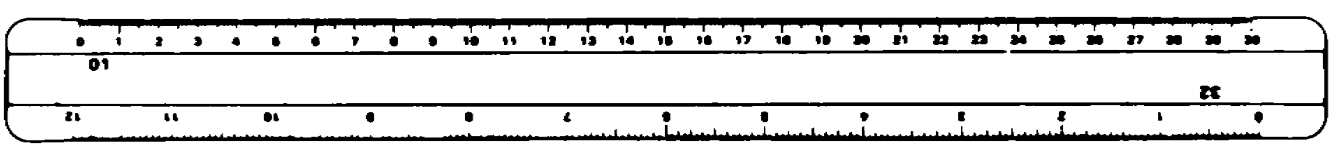
8. What is the measurement of line C-D? _______________



9. There are 10 decimeters in one meter and 10 centimeters in one decimeter. Mark one decimeter on the scale.



10. To measure millimeters, centimeters, and decimeters you use a _______________ _______________.



THINKING IN METERS

SOME RULES OF THUMB

MILLIMETERS (mm) are usually used when dimensioning thicknesses, such as sheets of metal, glass, etc.

8 mm = 5/16"
10 mm = 3/8"
16 mm = 5/8"
35 mm = 1 and 3/8"

1/2" = 12.7 mm
1/4" = 6.4 mm
1/8" = 3.2 mm
24 gage sheet steel = .635 mm (.025 inches)

CENTIMETERS (cm)

PIPE SIZES:
3/8" = 1 cm
3/4" = 2 cm
1" dia. pipe = 2.5 cm (25 mm)

BOOK SIZES:
equipment of this size
and sheets of paper:
8" x 10" = 20 cm x 25 cm
one foot = 30 cm+

DESK SIZES:
and equipment of this size
2' x 3' = 60 cm x 90 cm
20" high = 50 cm high+

WINDOW SIZE:
2' x 5' = 60 cm x 150 cm+

METERS (m)

DOOR SIZE:
6' 8" x 2' 8" = 2.00 m x .80 m

AVERAGE MAN'S HEIGHT:
5' 8" = 1.73 m

BUILDINGS:
20' x 40' = 6 m x 12 m
34' x 67' = 10 x 20 m

(meter continues)

ROAD SIZES:
20' wide = 6 m
30' wide = 9 m
40' wide = 12 m

KILOMETERS (km)

DISTANCES AND SPEEDS:
10 km = 6 miles
40 km = 25 miles
50 km = 31 miles
80 km = 50 miles
100 km = 62 miles

1 inch = 2.5 cm or 25 mm+
1 foot = 30 cm+
1 yard = 1 m+
1 mile = 1.6 km+
10 miles = 16 km

Note: + = some figures above are only approximate to make it easier to remember.

INVAR SCALE

SELF-TEST

1. What is the measurement from the 1 cm line to the fourth vertical line at the bottom of the scale?

   A. 1.400

   B. 1.410

   C. 1.140

   D. 1.114

   E. 1.00

2. How will the measurements be made from the Invar scale?

   A. Horizontal

   B. Horizontal to the parallel line

   C. Parallel to the horizontal line

   D. Next to the invar scale on the case

   E. On the invar scale

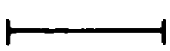
3. Using the bound in invar scale give the length of the following lines:

 A. 1.0 B. 1.5 C. 1.2 D. 1.6

 A. 2.90 B. 2.95 C 2.5 D. 3.0

 A. .05 B. .50 C. .60 D. 1.0

 A. 3.60 B. 3.5 C. 3.555 D. 3.55

 A. 1.752 B. 1.755 C. 1.65 D. 1.0

4. On the metric end of the invar scale what do the horizontal lines represent?

   A. 100th

   B. 1,000th

   C. 10th

   D. 10,000th

5. When using the invar scale, what is the only measurement that is estimated?

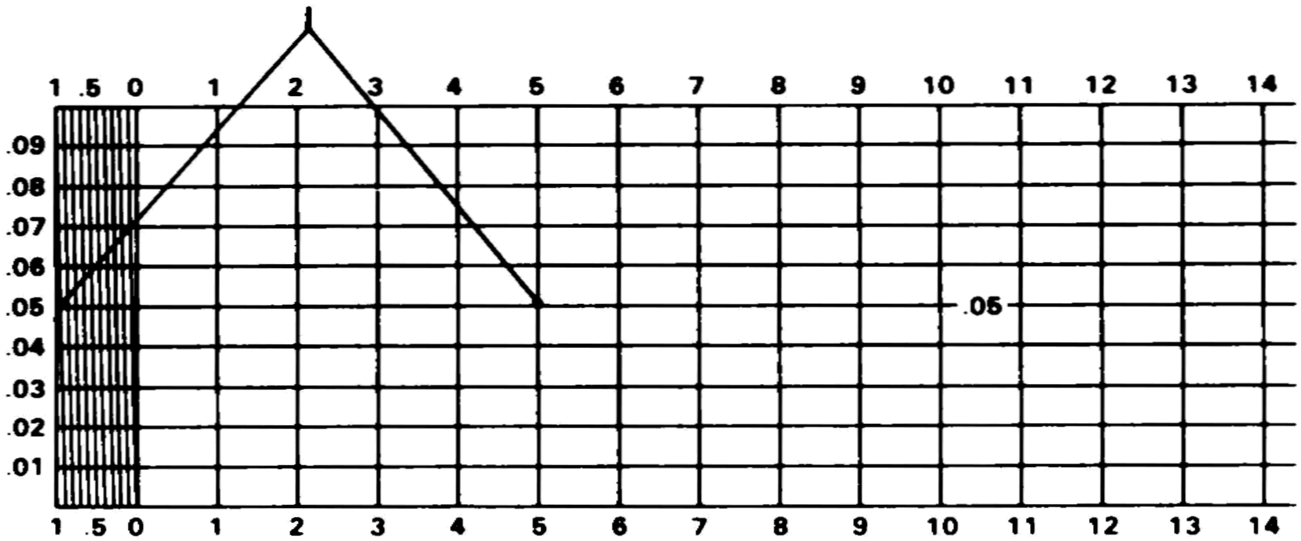
   A. cm

   B. 100th

   C. 10th

   D. 1,000th

6. What is the measurement shown on the invar scale below?



A. 6.00

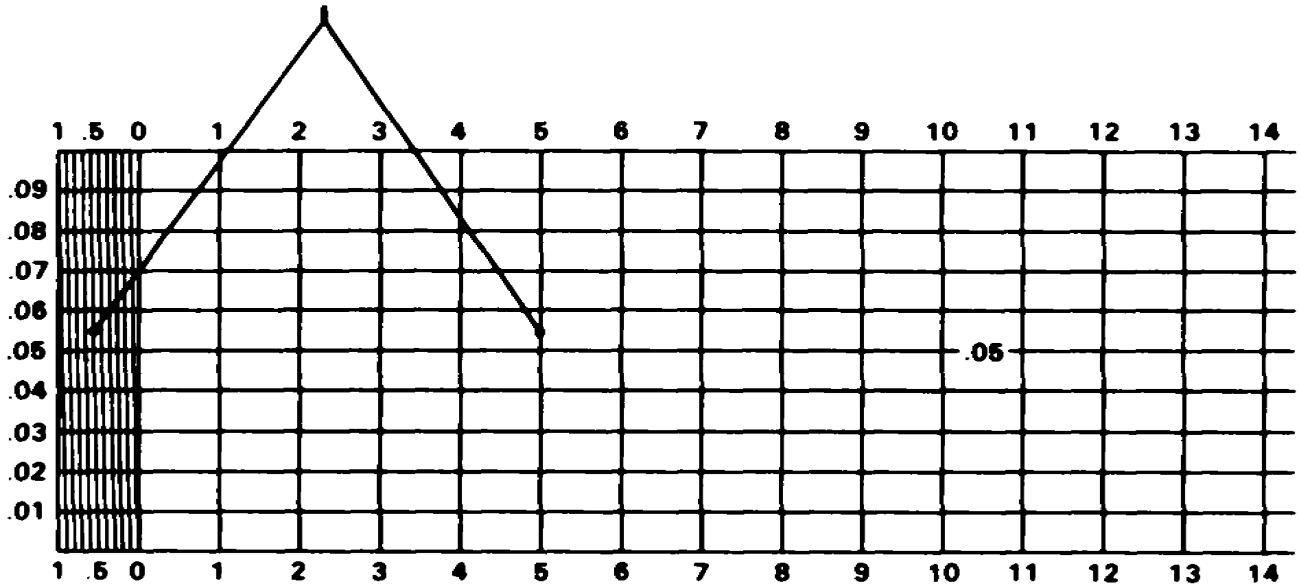
B. 5.95

C. 5.90

D. 5.59

E. 5.09

7. What is the measurement shown on the invar scale below?



A. 5.555

B. 5.550

C. 5.050

D. 5.005

E. 5.500

LESSON III SELF-TEST ANSWER SHEETS

ENGINEER SCALE

1. Large
2. Proper
3. Engineer's scale

   Architect's scale

   Metric scale

   Graphic scale
4. Six
5. 10

   20

   30

   40

   50

   60
6. Plastic
7. Slightly dampened
8. Left to right
9. Civil
10. Measure
11. Successive

SCALE		LENGTH
12.	1 in = 1 ft	3.3 ft
	1 in = 10 ft	26 ft
	1 in = 100 ft	172 ft
13.	1 in = 2 ft	5.9 ft
	1 in = 20 ft	49 ft
	1 in = 200 ft	445 ft
14.	1 in = 3 ft	9.5 ft
	1 in = 30 ft	102 ft
	1 in = 300 ft	651 ft
15.	1 in = 4 ft	14 ft
	1 in = 40 ft	104 ft
	1 in = 400 ft	795 ft
16.	1 in = 5 ft	15.3 ft
	1 in = 50 ft	142 ft
	1 in = 500 ft	1,235 ft
17.	1 in = 6 ft	19 ft
	1 in = 60 ft	150 ft
	1 in = 600 ft	550 ft

METRIC SCALE

1. Metric scale
2. Centimeters
3. Fractions
4. Two
5. Ten
6. 1/2
7. 9.5
8. 1.55 cm
9. 10 cm
10. Metric scales

INVAR SCALE

1. A
2. C
3. B, C, B, D, B
4. A
5. D
6. A
7. B